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1919.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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President New England Water Works Association,
1919.

New England Water Works Association.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE SHIPPING SITUATION AND THE CONSTRUCTION OF THE SQUANTUM DESTROYER PLANT.

BY THOMAS C. ATWOOD, RESIDENT SUPERVISING ENGINEER.

[*September 11, 1918.*]

At the beginning of the war with Germany the Government was confronted with many problems, not the least of which was the problem regarding shipping. As is generally known, the most serious threat against the successful prosecution of the war, and especially to our own participation, was the unrestricted use of submarines by Germany. This action by the enemy not only threatened to destroy the transports, preventing us from sending an adequate army to Europe, but also to prevent us from supplying our own troops and those of the Allies.

The only really effective means of combating the submarine has been found to be warships of a type known as "torpedo boat destroyers," and the first action of the Navy Department was to call for the rapid construction of a large number of these. Other boats were pressed into service, of course, and a smaller class, which could be built more rapidly, namely the 110-ft. submarine boat chasers, were also contracted for; but these were of little assistance in convoying troops and supplies across the ocean, for which purpose the destroyers were absolutely essential.

The 110-ft. boats were very useful in Europe, so long as submarines operated within about one hundred miles of shore, but the submarines soon began to carry their operations far beyond this limit, and destroyers were necessary for offensive operation

against them, wherever they might be found, although an intermediate class was designed for special service in this particular respect. This was the 200-ft. class, known as the "Eagles." None of these, however, have as yet been put into service.

Destroyers, then, were the one thing that we needed, and needed in large numbers, not only to wage offensive war on the submarines, but to convoy our ships across the ocean, both the transports and the supply ships. The convoy system was soon developed to protect merchant ships, as well, and so effective has this system become that losses were cut down from nearly ten per cent. to about one per cent.

When we entered the war the number of destroyers in the English, French, and Italian navies was considerable, but they were devoted almost entirely to convoying troops and protecting the main fleets against submarine attacks. Merchant ships had to get along the best they could. On the most important station which the British had for protecting commerce there were only seven destroyers, and it went without saying that these boats could not be used to convoy ships, as they had to remain on the station to chase down every submarine which was reported.

It may be well to give a brief summary of the general shipping situation. In 1914 there were something like 53 000 000 tons of shipping, — including the Great Lakes and the coastal shipping and everything, — and of that amount about 18 000 000 tons have been destroyed by the submarines and about 5 000 000 more of German shipping were interned, so that only about 30 000-000 tons remain of the original amount. To this must be added the 10 000 000 tons which have been built during the war, a much smaller amount than usual, of course, because the British construction was very largely cut off when the war started. It is only within the last year that the British have started their shipyards going again on merchant shipping, and they are now approaching their normal yearly output. There is now possibly 40 000 000 tons available. If the war had not occurred and normal building had proceeded, there would have been about 65 000 000 tons available now; so it is easy to see how serious the shortage is. The needs of the governments are so large that a very small amount remains available for private use.

The situation has been met in this country in two ways: First, by the building of destroyers to protect what shipping we had left; and, second, by building additional shipping as rapidly as possible. The destruction program of the Germans, beginning with February, 1917, called for the destruction of about a million gross tons of shipping per month, and they actually approached this at first; but now the destruction has been reduced, in August, 1918, to around 250 000 tons per month; and during this present summer the shipbuilding has increased so that we have passed the destruction limit and are actually building more ships than are being sunk every month by the submarines. We have just passed the low point and are starting on the upward curve however, so it is going to be months and years before we catch up to where the shipping should be.

It is pleasing to note that the submarines have also been destroyed. The best information I have been able to secure is that about 250 or, possibly, 300 submarines have been built by Germany, and of these probably 150 have been destroyed, leaving 100, or possibly 150, still operating, and of these not more than one third are at sea at one time.

The convoy system has greatly helped in the matter of preventing submarine losses of shipping, because the ships go under the convoy of destroyers, and it is an extremely risky matter for a submarine to show itself anywhere near a destroyer, for if a destroyer does not get it with its guns it is very likely to with the depth bombs.

Of course the wastage of shipping has not been entirely due to the submarines, but it has been due also to navigation losses, which are much greater now on account of war conditions, so many lighthouses and lightships being out of commission, and ships running without lights and without fog-horns are very likely to collide, or much more likely than in ordinary times.

The shipbuilding program in this country has been carried forward very rapidly both by the Navy Department and by the Shipping Board, and while the old yards — the ones which were in the service at the beginning of the war — have been almost entirely occupied with the Navy work, a great many new yards have been built by the Shipping Board; so that now that Board has

159 yards in operation, with some 750 ways. About half of the yards build steel ships and the other half build wood, composite, and concrete ships. That the production is increasing very rapidly is evidenced by the fact that this summer the number of rivets driven, which is the index to the amount of steel tonnage being turned out, has increased about 100 000 rivets each month, it having been 400 000 rivets in April and now being double that number.

The Navy Department confined its program almost entirely to destroyers at first, but within the last two or three months orders have been given to go ahead with the capital ships, which shows that the submarine situation is well in hand, or else every effort would still be devoted to building destroyers.

The shipbuilding situation is probably more responsible for the shortage of labor in this country than any other industry. When one realizes that before the war we were only turning out about 250 000 tons of shipping per annum, while now we are aiming at 10 000 000 tons per annum and will actually run up next year, probably, to 6 000 000, one can see what a tremendous overturn there has been in the business. The number of people engaged in shipbuilding before the war was not over 50 000, while now there are nearly 1 000 000 people, if we include both the Shipping Board and the Navy Department. The Navy Department has had about as much work on hand as the Shipping Board, until recently. This has created a labor situation which is unique in the history of this country because so many different men are engaged in shipbuilding who never were engaged in that class of work before.

This is the reason why shipping has not increased at a greater rate. In another year, when these men have been trained to be mechanics, there is going to be a very great increase in the amount of shipping put out, because shipbuilding methods have been improved so greatly and the number of types and sizes of ships reduced to such an extent that a man should turn out more tons per annum than formerly. Before the war it was a very good yard which would turn out 20 tons per annum per man of merchant shipping, and that is cut down now by inefficiency in such yards to about 15 tons, and in some even less. But there are

yards in the country which are turning out as high as 35 tons, and the reason is found in the fact that these yards are ones which got started early and corraled all the good mechanics there were and would not let go of them, and the others had to take what was left.

The shipbuilding facilities of the country were found inadequate to produce the number of destroyers needed within the time required, so extensions to existing yards were made and in addition the large plant at Squantum was projected, this being built as a strictly Navy plant, designed entirely for the construction of destroyers and boats of similar size. The plant cannot be used for the building of larger ships without the construction of extensive additions, because the buildings and machinery are planned for destroyers, and the ways are not heavy enough for larger craft.

Everything is laid out in this plant for the most rapid construction possible. Before the war it was customary to take from eighteen to twenty-four months to turn out a destroyer, but under the pressure of war conditions this time has been reduced at old plants to five or six months, and it is hoped at the Squantum plant that this time will be reduced even more.

One destroyer has been launched in fourteen days from the time of laying the keel; but this is what might be called a " freak performance." Every piece of steel which was required in that boat — and there are some 24 000 different pieces — was ready to put into place before the keel was laid; months had been spent in getting it ready. This " stunt " was pulled off at the Mare Island Navy Yard, California.

In a plant like that of Squantum, however, turning out destroyers in regular succession, it should be possible to build a boat, ready for launching, in about two and one-half months, and to outfit her in about two months more, making the minimum time for average construction four and one-half months. This, however, can only be attained by an efficient organization working at top speed.

The present contract calls for 35 vessels to be built at Squantum, all within twenty-one months from the time the work on the yard itself was started; and this, it will be seen, is much less time than it formerly took to build one destroyer in an established yard.

The construction of the Squantum Destroyer Plant was begun on October 6, 1917, and was carried on, day and night, throughout the following winter, which all remember as being the most severe on record. A working force of about 6 000 men was employed, and the construction plant was much larger than usual in order to procure the rapidity of work and comfortable conditions for the workmen.

The design of the plant was carried on at the same time as the construction, and the engineers succeeded in keeping ahead of the work in almost all instances, there being no delay of any consequence. They had had a short time, perhaps a month before the contract was awarded, in which to prepare for the construction work, but only general decisions could be made in this time, so that practically all the detail work had to be done during the construction period.

The plant occupies a tract of some 700 acres, facing Dorchester Bay in Boston Harbor, on the Neponset River, and lying entirely within the city of Quincy. The plant proper occupies an area of about 90 acres, directly on Dorchester Bay, part of this area being above tide level and part of it being salt marsh with from 5 to 15 ft. of mud overlying the solid clay beneath. A channel giving 12 ft. of water at mean low tide was dredged from the main Dorchester Bay channel into the plant, and a large launching basin dredged out to provide for handling the boats when launching and outfitting. This dredging was done by hydraulic dredges which discharged the excavated material on to the marsh and made ground on which to build a large part of the plant.

The foundations for the buildings consisted of spread footings where solid ground was available, and concrete piles elsewhere, except that foundations of the wharves were all constructed of oak piles.

The buildings proper were divided into two classes, both being permanent construction. The high buildings, all of which contained traveling cranes, were of steel frame construction, glass sides and wooden roofs, the latter being mainly of sawtooth construction. The low buildings, and also the main office building, were of mill construction.

LAUNCHING FIRST DESTROYER, JUNE 18, 1918.

ICE CONDITIONS DURING CONSTRUCTION OF WHARF.

The buildings are thoroughly sprinklered; the wet system being used in heated buildings and the dry system in unheated buildings.

This plant is unique, in that the ships are built entirely within the new buildings, both before launching and afterwards. By this means, it is expected that at least two months will be saved in the building of the destroyers under the present contract, and the cost of the roofs — perhaps $2 000 000 — is so much less than the possible saving, due to earlier construction of the destroyers, that it becomes an economical proposition to completely enclose the building ways and the outfitting basin.

The plant is laid out for the most economical construction possible of the destroyers, and is thoroughly equipped with every possible labor-saving device. All steel is taken out of the railroad cars by overhead cranes and stacked in numbered racks, so that each individual piece is immediately available, and, when needed, is taken on cars into the adjacent fabricating shop, where it is worked into final shape and carried into the next building to be assembled into bulkheads, or placed directly on the boats.

Overhead cranes carry the fabricated steel from the assembly building directly to the boats, each boat being served by two 3-ton cranes, one of which can drop steel directly over the center line of the boat.

The lighting of the buildings is so good that no artificial light is needed, but thorough light is provided for working at night.

Compressed air and electrical power is distributed to all parts of the buildings from the main power house, where current is received from the Boston Edison Company, and transformed or converted into the various forms necessary. Directly connected compressors supply the compressed air needed.

A complete galvanizing shop, for galvanizing material up to plates 30 ft. long by 5 ft. wide, is adjacent to the assembly shop.

A large machine shop provides means for doing all machine work on the ships, which it is advisable should be done at the plant.

One of the most important outfitting shops is the pipe shop, in which is done all the copper, brass, and iron piping work, of which there is a vast amount on each destroyer.

INTERIOR OF WET SLIPS.
(Fitting-out Basin.)

INTERIOR OF ASSEMBLY BUILDING.

The turbines driving the destroyers have a total horse-power of about 28 000, so that it may readily be seen that the piping required between the boilers, turbines, compressors, and all the auxiliary machinery is very large, and all has to be specially made up in order to fit in the required space available.

Another large shop is the sheet-metal shop, where all the light metal work is done; the shop being equipped to handle steel plate work up to $\frac{5}{16}$ in. in thickness. Here the up-takes, smoke stacks, etc., are made, as well as innumerable metal interior fittings.

Additional shops are provided for the riggers, outside mechanics, carpenters, electricians, and the yard maintenance force.

Storage for the necessary materials other than the heavier parts is provided in the storehouse, and storage for the heavier material which comes in ready for placing in the ships is provided in the warehouse. Here, such equipment as pumps, blowers, etc., is kept until time for installation.

The yard is served by railroad connection from the New York, New Haven & Hartford Railroad, — Old Colony Division, — and a complete system of tracks allows the material to be taken to any part of the yard or buildings.

Locomotive cranes are provided for handling material which is desired to be stored in the open in various parts of the yard, and for handling coal and similar materials.

A system of macadam roads was built to give access to all the buildings, and the remainder of the ground is graded to provide for the greatest usefulness of the space available. As a large part of the area was filled in by the hydraulic dredge with material from the launching and outfitting basins, and as this material consisted mostly of clay, it was necessary to place 12 to 18 in. of dry, sandy gravel over the top of the hydraulic fill in order to make it possible to use the surface. This material was obtained from gravel pits in Wollaston and East Weymouth.

The plant proper is completely fenced in, with lights provided to make guarding easy, and at the gates are special houses built for checking employees in and out, and a service building containing a well equipped hospital and employment office.

A restaurant, with a seating capacity of 1 500, is provided for use of the employees, and the bunk-houses, built for construction

Construction of Wet Slips.

Plate Storage Yard.

work, have been left for use in housing employees of the plant if this should prove necessary.

The yard is served from the Metropolitan water system, a complete system of piping extending to all buildings. In addition to this there is a complete fire protection system with pressure supplies by a 100 000-gal. tank on a 125-ft. tower. Two 1 000-gal. fire pumps, electrically driven, for taking water from Dorchester Bay, are provided for use in case of a large fire, but the system is maintained full of fresh water as a rule.

Accessory plants were built at Buffalo, N. Y., Providence, R. I., and Cambridge, Mass., for the construction of turbines, boilers, and pumps, respectively, all the plants being under the same general appropriation and management.

The plant was built under the supervision of the Navy Department, Admiral H. H. Rousseau in charge of new plant construction under the Bureau of Yards and Docks, and the field construction in charge of the speaker, as supervising engineer, assisted by Mr. C. L. Hammond and Mr. F. I. Winslow. The auditing was in charge of Paymaster Alvin Hovey-King, U.S.N., with Assistant Paymaster C. L. Bates, U.S.N., in direct charge.

The plant was laid out by the Bethlehem Shipbuilding Corporation, Mr. J. W. Powell, vice-president, and Mr. H. G. Smith, manager.

The works were designed and construction supervised by Messrs. Monks and Johnson, of Boston, the engineering work being in direct charge of Mr. Johnson of this firm, assisted by Messrs. John R. Nichols, M. Linenthal, R. R. Burnham, H. O. Jackson, L. I. Killian, R. J. Fogg, and H. A. Hoyt.

The contractor for all plants was the Aberthaw Construction Company, of Boston, Mr. L. C. Wason president, Mr. J. A. Garrod general superintendent, and Mr. W. H. Ryerson superintendent on the Squantum plant.

A great deal of credit is due all the interests concerned for the hearty coöperation which all endeavored to give, to secure the best and most rapid results possible.

The completion of this large plant within the time allotted and the severe weather encountered reflects great credit upon the entire construction force.

The work was far enough along so that active work on building destroyers began January 1, 1918, and the plant substantially completed before June 1, 1918. The keels of the first five destroyers were laid April 20, 1918, and the first boat launched July 18, 1918.

THE MEASUREMENT OF RAINFALL AND SNOW.

BY ROBERT E. HORTON, CONSULTING ENGINEER, ALBANY, N. Y.

Introduction.

In this paper the word "rainfall" will sometimes be used to describe all those forms of atmospheric precipitation which are ordinarily measured and included in rainfall records, and which consist mainly of rainfall and snow. Other forms of precipitation, including dew, frost, and mist, — which for the most part are not ordinarily included in rainfall records, — will not be discussed.

Probably almost every one who has kept or used rainfall records has had some question lurking in his mind at times as to the accuracy of such records. Again, the question often arises as to whether a rainfall record taken at one location will furnish a reliable indication, either of the mean, the annual, or the rainfall in individual storms at near-by locations, or over any considerable area surrounding the rain gage.

The object of this paper is to describe methods of measuring of rainfall and snow, and to discuss the errors and accuracy of such measurements, with a view to suggesting methods of securing rainfall records having the highest possible degree of accuracy and usefulness.

Some attention will be given to the question of the reliability of the results obtained from a single rain gage as applied to larger or smaller areas around it. This ever-recurring question is of special importance in connection with gravity water-supply systems dependent upon small drainage areas, since it does not often happen that there is more than one rain gage located within or closely adjacent to a water-works catchment basin of, say, ten square miles area or less.

Neither the causes of rainfall, its characteristics or variations, nor methods of analysis and use of rainfall records, is here considered. It is conceived that a discussion of these subjects might

form the basis of a far more interesting paper than can be evolved from the relatively dry details of the technique of rainfall measurement. Inasmuch, however, as there are numerous rainfall records maintained in conjunction with water-works systems, — especially throughout New England, — and the results seem to justify a general increase in the maintenance of such records by water-works engineers, officials, superintendents, and reservoir keepers, it seems worth while to devote some attention to the subject of the best methods of locating rain gages and of keeping records of rainfall and snow.

As a foundation for this discussion and as affording added interest to the subject, the development of the rain gage and the methods and extent of rainfall observations in various countries are briefly treated.

Early Rain Gages and Rainfall Records.

Geologic considerations indicate the occurrence of rain back to the dawn of stratigraphic history. Direct evidence of the nature and occurrence of rain in early geologic times is found in rain prints on rocks. Such records, showing the actual impressions made by raindrops on soft beds of clay, are found in the carboniferous rock in England and in the still earlier rocks in Glacier National Park in the United States. Such rain prints probably represent light showers which occurred during low tide, the soft mud in which the imprints were formed being covered with sediment immediately after the rain and so preserved.

As regards written records, it seems there must have been some sort of a rain gage in use in India as early as the fourth century B.C. In a book, "Arthastra," or the Science of Politics, by Chanakya, the famous minister of Chandragupta, the founder of the Maurya dynasty in India, and the grandfather of Asoka, there are certain statements from which we are led to believe that the Indians of the fourth century B.C. had a good idea of meteorology. In the chapter on the "Superintendent of Agriculture" is found the following:

"The quantity of rain that falls in the country of Jangala is 16 dronas; half as much more in Anupanam countries; 13½ dronas

in the country of Asmakas; 23 dronas in Avanti, and an immense quantity in Apparantam; the borders of the Himalayas, and the countries where water-channels are made use of in agriculture." *

In the Mashnah, a collection of religious writings of the first century, there have been found recorded measures of rainfall in Palestine during the first century of our era. These are probably the first quantitative observations of precipitation now in existence. Hildebrandsson states that these observations agree as to quantity of rainfall with modern pluviometric records at Jerusalem. (M. W. R., June, 1916, p. 345.)

So far as rain gages of modern types are concerned, it is known that they have been used since the days of Leonardo da Vinci, 1452–1519.

The invention of the rain gage is, however, often attributed to an Italian, Benedetto Castelli, who, in June, 1639, informed Galileo that he had measured the rainfall with a "vase one spanne in depth and half a spanne in diameter." Its invention is also sometimes credited to Sir Christopher Wren, in 1663. Wren also devised a recording rain gage in 1670.

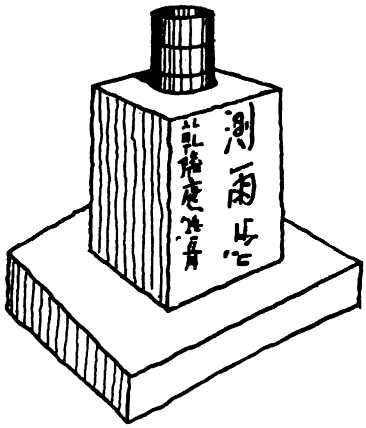


FIG. 1. THE OLDEST RAIN GAGE. ERECTED AT TAIKU, 1770.

Dr. Y. Wada, director of the Korean Meteorological Observatory, has shown that rain gages were in use in Korea as early as 1442. The dimensions of the ancient gage were: depth, 30 centimeters; diameter, 14 centimeters. A gage of the period of 1770 was found by Wada on an inspection trip actually in use at the observatory of Chemulpo, Korea. On the granite pillar of the gage represented in the illustration (Fig. 1), found at Taiku, are engraved three large Chinese characters meaning "Instrument to measure rain," and seven

* Jogindra Nath Sammadar, Hararibagh, Bengal. *Quar. Journ. Roy. Met. Soc.*, January, 1912, pp. 65–66.

smaller characters meaning " Constructed in the fifth month of the cycle of the year," a date in the Chinese calendar corresponding to 1770. This is evidence that rain observations began in Korea two centuries before they were made in Europe, and, what is more remarkable, there appears to have been an udometric survey, or network of rain-reporting stations. The reports were probably used in connection with the rice crop.

A conical rain gage intended to multiply the depth of precipitation so that it could be measured accurately was invented and used by the physicians Kanold and Kindmann, of Breslau, between 1717 and 1727.

A conical rain gage was introduced in the United States of America by Simeon DeWitt, of Albany, in 1807, and described in a paper before the Albany Institute.*

The earliest modern rainfall records were instituted at Paris in 1668. The longest continuous record is that kept at Padua, begun in 1725 and still continued.

Probably the earliest long record kept in the United States was that of Professor Winthrop, at Cambridge, Mass., which was begun in August, 1749, and continued until the day of the battle of Lexington, 1775. This record is given by Goodnough.†

A record at New Bedford, Mass., was begun by Samuel Rodman in 1814 and was continued down to 1898, covering one hundred and thirteen years.‡

DATE OF BEGINNING OF EARLY PRECIPITATION RECORDS.

Location.	Date.
Paris, France	1668
Townley, England	1667
Ulm, Germany	1715
Padua, Italy	1725
Milan, Italy	1764
New Hartford, Conn	1804
New Bedford, Mass	1814
Boston, Mass	1818
Albany, Troy, Utica, N. Y.	1826

Most of these records have been kept continuously to the present time.

* See *American Journal of Science and Art*, Vol. 22, pp. 321–4.
† JOURN. N. E. W. W. ASSOC., September, 1915, p. 332.
‡ JOURN. N. E. W. W. ASSOC., September, 1915, p. 365–7.

DISTRIBUTION OF RAINFALL RECORDS.

Rainfall gaging stations are generally distributed over the British Isles, United States, Southern Canada, Germany, Austria, France, Japan, Italy, India, Australia, Java, and Argentina, and to some extent in China, Mexico, Russia, and the Philippines, South Africa, and Denmark.

Dr. Buchan (Vol. 3, Meteorology, Bartholomew, Physical Atlas, London, 1899) states that there are 30 000 stations for observing rainfall, scattered over the continents and islands of the globe. There is one station or more to every 40 square miles in Jamaica, Barbados, St. Kitts, Great Britain and Ireland, Denmark, Saxony and the Straits Settlements, Victoria and Mauritius. For Europe, United States, India, and Australia, the general average is about one station for every 2 000 square miles. In the thickly settled portions of the United States there is about one station to 500 square miles, the usual practice in the eastern United States being the maintenance of one station in each county. In sparsely settled regions in western United States there may be only a single station in an area of 16 000 square miles.

There are about 2 000 rainfall records in the United States having a duration of twenty-five years or more, and probably an equal number of shorter records of ten to twenty-five years' duration. At the present time there are about 200 regular United States Weather Bureau stations equipped with recording instruments. There are 3 000 stations, the pluviometric results for which are regularly reported in the publications of the United States Weather Bureau. France has 2 000 stations, and England about 5 000.

Numerous rainfall records were established in the period 1825 to 1850 at the academies in the state of New York. The earlier records in the western states were often kept at forts and barracks.

VARIOUS FORMS OF RAIN GAGES.

The earliest rain gages were mere prismatic containers, the depth of catch being measured directly. So far as I can learn, the Simeon DeWitt or Albany gage (Fig. 2) was the first having a

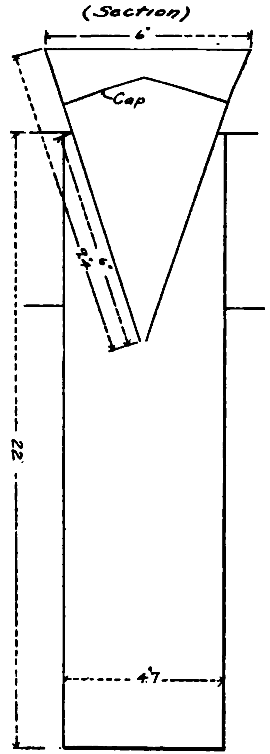


Fig. 2. DeWitt Rain Gage.

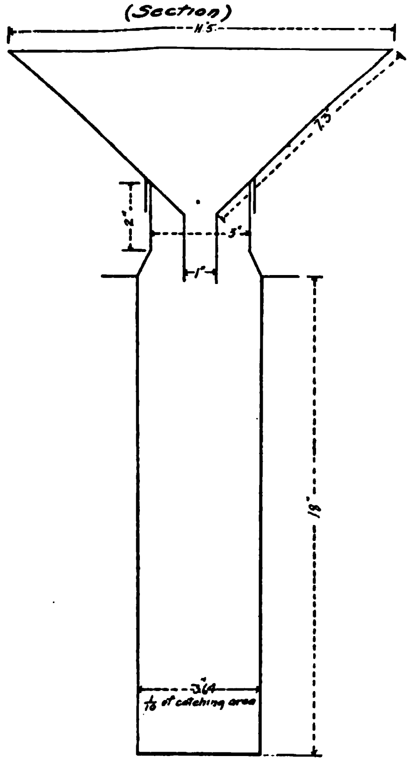


Fig. 3. Smithsonian Rain Gage.

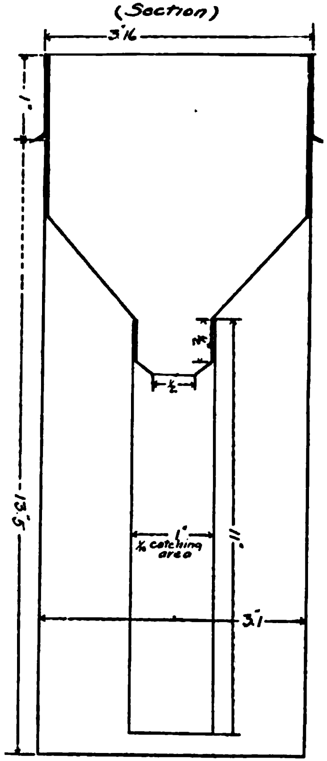


Fig. 4. Fuertes Gage.

funnel with a small orifice intended to reduce evaporation loss. This seems also to have been one of the earliest gages in which the depth of rainfall was multiplied by catching and measuring it in a receiver, smaller in diameter than the funnel of the gage, thus facilitating accuracy of measurement. These two points represent practically the only significant improvement in modern rain gages over the most primitive prismatic types. There is no reason to doubt that so far as the actual catch is concerned the Korean gage (Fig. 1) is as accurate as the best modern gage. The errors and uncertainties of such gages result from evaporation loss and inaccurate measurement of the catch.

In the earlier days, many special types of rain-gage funnels were devised, such as the inverted cone of the DeWitt and Smithsonian gages, and the splayed rim surrounding the funnel of the Von Bezold gage. Fortunately, as will be shown later, these devices do not seem to have materially reduced the accuracy of the records obtained. Such devices have, however, mostly fallen into disuse, and cylindrical gages are now in general use the world over. Some of the earlier type of gages are shown in Figs. 2 to 5 inclusive. Figs. 6 to 10 inclusive show the principal forms of gages now in use in the United States, England, India, and Continental Europe. They are practically identical in the principles of their construction, but vary in size, methods of setting, and methods of measuring the rainfall caught. The names, sizes of funnels, and usual heights of funnels above ground, of the principal rain gages now in use, are shown in the following table.

CHARACTERISTICS OF VARIOUS RAIN GAGES.

Name.	Used in	Diameter, In.	Usual Height.
Meteorological Office	England	8	
Snowdon	England	5	1 ft.
Symons	India	5	1 ft.
Hellman	Prussia		1 meter
Simeon DeWitt	Early U. S. A.	6.00	8 ft.
Smithsonian	Early U. S. A.	11.50	Flush
Fuertes	Old N. Y. State	3.16	
U. S. Weather Bureau	U. S. A.	8.00	4.5 ft.
Friez recording	U. S. A.	10.50	
Glaisher	England	8.00	

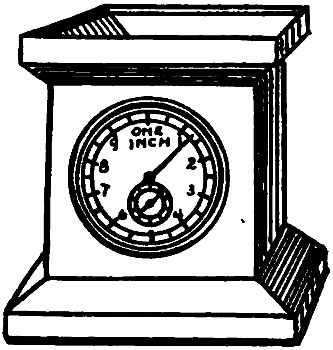


FIG. 5. "WILSON" SELF-REGISTERING RAIN GAGE.

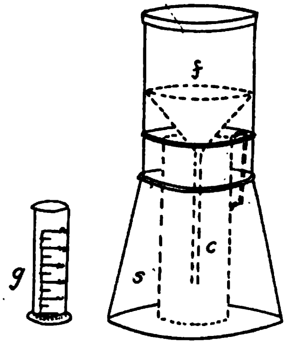


FIG. 6. RAIN GAGE, SNOWDON PATTERN, WITH SPLAYED BASE, BRITISH METEOROLOGICAL OFFICE PATTERN.

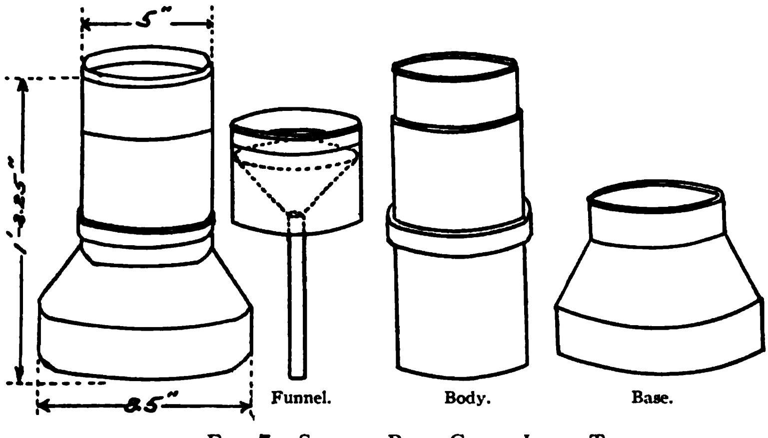


FIG. 7. SYMONS RAIN GAGE, INDIA TYPE.

With the English types of gages, including the Symons, Snowdon and Meteorological Office gages, a graduated measuring glass is used; with the Glaisher and Hellman gages the rain is caught in a metallic receptacle and afterward poured into the measuring glass. The Glashier gage (Fig. 8) has an inverted siphon outlet funnel affording a water seal intended to prevent evaporation.

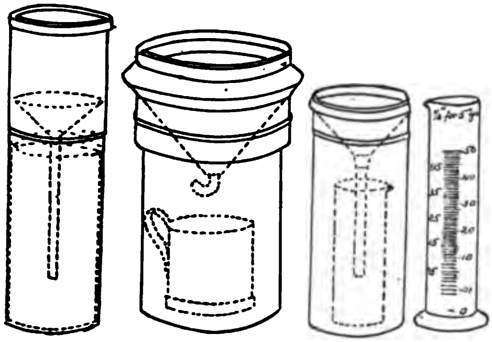
The Casella gage has a special insulated outer jacket which will prevent freezing of the water in the gage in ordinary winter weather. Inasmuch as leakage of the overflow can of gages of the U. S. Weather Bureau type, resulting from freezing, is a not uncommon occurrence, the use of the insulating jacket seems to merit consideration.

Gages with square funnels have occasionally been used, such, for example, as the Wilson gage (Fig. 5) an English instrument having a dial and hands, by which the amount of rain caught is indicated directly in inches and hundredths.

United States Weather Bureau Rain Gage.

The accompanying Fig. 10 shows the form of non-recording rain gage in common use in the United States. The diameter of the gage funnel, A, is 8 in.; the diameter of the inner tube, C, is such that, allowance being made for the measuring stick (not shown) the area of cross-section of the tube equals 0.1 the area of the mouth of the funnel, so that the depth of rainfall is multiplied ten times. A cedar measuring stick about $\frac{3}{32}$ in. thick by $\frac{1}{2}$ in. wide is used. This is graduated in inches and tenths, in such a manner that an actual depth of 1 in. in the inner or reservoir tube of the rain gage reads 0.1 in. on the stick. The depth of moistening of the portion of the cedar rod inserted in the water in the inner tube shows clearly after the rod is withdrawn for the purpose of taking the reading.

There is no standard or uniform height above ground at which rain gages are placed in the United States. As a rule, the nearer the ground the more accurate is the record obtained by a rain gage. Inasmuch, however, as the gage should be high enough to prevent interference by children and animals, a height of the top of the funnel of 4.5 ft. is found convenient.



Standard Snowdon. Glaisher. Symons. Standard Camden Measure.

FIG. 8. BRITISH RAIN GAGES.

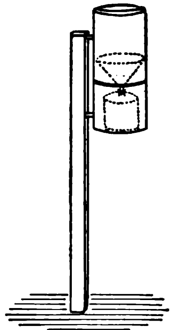


FIG. 9. HELLMAN RAIN GAGE.

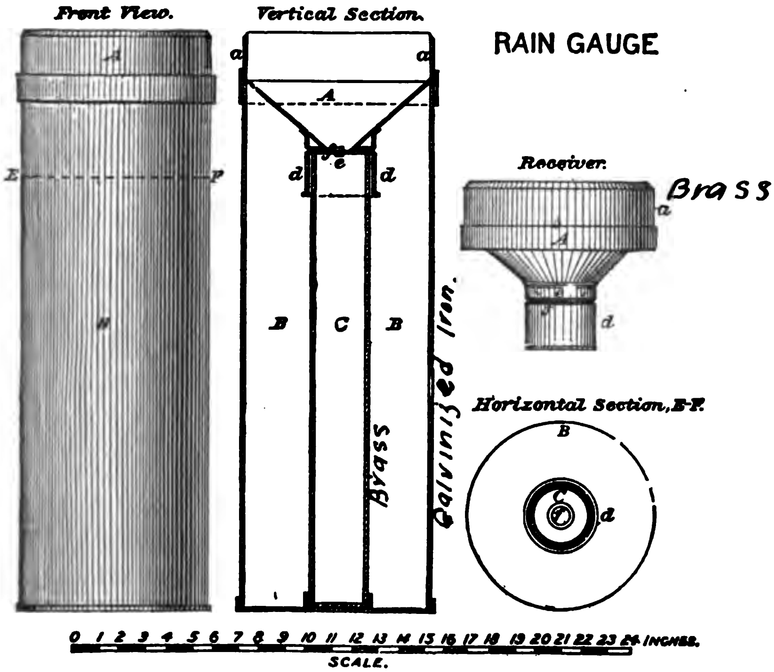


FIG. 10. U. S. WEATHER BUREAU RAIN GAGE.

In the winter time the funnel *A* and the measuring tube *C* are removed, and only the overflow can *B* is left in position. One method of measuring snow caught in the overflow can is to melt the snow, pour the water into the brass measuring tube, and measure it in the usual way with the cedar stick.

"The method just described is objectionable, owing to the time required and to the loss of the snow or water by evaporation. The following plan is much better: Take the overflow into a room and pour it into one measuring tube full of water to the brim, preferably warm. In cases of deep snowfall more water will be required. This will melt, or at least reduce to a fluid slush, a considerable amount of snow. The measuring tube should then be filled to the brim from the melted contents of the overflow and emptied; thereby discarding a quantity of water equal to that added. The remaining water in the overflow when measured in the tube then gives the actual depth of melted snow." (Circular E, U. S. W. B.)

Mountain and Tropical Gages.

In regions having excessive rainfall it is necessary to provide rain gages capable of retaining a much larger amount of precipitation than can be stored in the ordinary type of gage. Special deep gages, sometimes called "mountain gages," are available for this purpose, and the English mountain gage of Negretti and Zambra will hold 27 in. of rain. In mountain regions where regular observers cannot be obtained, and gages can only be occasionally visited, good records of the total monthly precipitation can be obtained by the use of such gages, where otherwise data would be wholly wanting. Special attention is directed to this gage in this connection, as water-works engineers often desire numerous records of rainfall in connection with their reservoir systems but are hampered in procuring them for want of observers.

It is suggested that one or two ordinary gages, read daily, in conjunction with several gages of the mountain type read weekly or monthly, will oftentimes prove a valuable combination. One of the difficulties of the use of gages read occasionally is the avoidance of loss of rain caught by subsequent evaporation.

It is suggested by J. C. Alter (*Monthly Weather Review*, Novem-

ber, 1907, p. 511) that by placing 0.2 in. of pure olive oil on 0.2 in. of water in a regulation Weather Bureau pattern 8-in. rain gage, with the funnel receiver, but without inner tube, and exposing the gage in the ordinary manner, the rainfall for a considerable period may be caught and retained with but little loss by evaporation. Experiments by Hall, using such a gage in parallel with a Weather Bureau tipping-bucket gage, showed a deficiency of three per cent. for the gage containing olive oil for the period April 16 to November 3, 1907, with a total rainfall of 7.77 in. Hall found that in light showers the fine drops did not penetrate the olive oil but remained supported on it and were lost by evaporation.

Recording Rain Gages.

The type of recording rain gage in most general use in the United States is the Friez tipping-bucket gage, Fig. 11. This has a funnel 10.5 in. in diameter, and, like the Weather Bureau gage, it has a brass measuring tube having an area one tenth the funnel area. The tipping bucket has two compartments, each holding .01 in. depth of rain. The weight of this rain tips the bucket, forming a contact and closing an electrical circuit, by which the exact time of each tipping of the bucket is recorded on the drum of a chronograph. This is a very satisfactory instrument in most respects. Obviously, one compartment of the bucket may remain partially filled when the rain ceases, and if this water does not evaporate the bucket will tip before .01 in. is fallen in the next subsequent rain. In very light showers this throws some error into the record as regards distribution of the rain, and makes it impossible to determine the rainfall duration with precision ex-

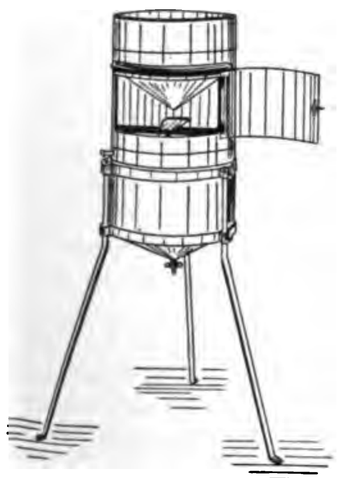


FIG. 11. TIPPING-BUCKET GAGE.

cepting for the time elapsed between the first and last hundredth recorded.

In very intense rains enough rain may fall during the time required to overcome the inertia of the bucket and water contained therein to produce an appreciable and often considerable deficiency in the recorded amount, although the amount subsequently measured in the brass tube will be correct.

The Friez gage cannot be used in freezing weather or to catch snow. Records of the intensity of precipitation in winter are generally of less importance than in the summer time. They are nevertheless desirable. The Casella tipping-bucket gage, made in London, contains a snow-melting device permitting its use throughout the entire year. Lamps or oil heaters are objectionable for several reasons. There should be no great difficulty, however, where electrical current is available, in arranging an electrical heating coil which would keep the gage interior warm enough to permit the use of a recording gage throughout the year, although the cost of current would be appreciable.

Full descriptions of the numerous types of recording rain gages in use in England and elsewhere are unnecessary here. Some of these, including the Fernley, Halliwell, and Hyetograph, are integrating or float gages and record graphically the total amount of rain which has fallen at any given moment. Such gages are sometimes provided with automatic siphons which empty the measuring tube when a certain amount of rain is caught, and return the pen of the recorder to the zero line. In this way a record having a large vertical scale is obtained on a relatively narrow record sheet. It is nearly if not quite as difficult to determine the exact time of beginning and ending of rain with such gages as with those of the tipping-bucket type. They give, usually, more satisfactory records in rains of very high intensity.

Charles F. Marvin, chief of the United States Weather Bureau, has designed a seven-day recording rain gage of the float type, in which the recording pen traces a spiral line on the record sheet, wound around the drum of the chronograph, in a manner similar to the operation of the Friez tipping-bucket gage. In the Marvin gage, as the rain accumulates in the gage well, the float rises, and the chain connecting the float to a counterweight and running

over a pulley actuates a cam which moves the recording pen laterally back and forth over a range of one-half inch for each one-half inch of rain caught in the gage.

In this way the scale of the record is multiplied by two. The movement of the pen forms a zigzag line changing its direction for each one-fourth inch of rain in somewhat the same way that the pen of the Friez gage changes its direction of motion for each .05 in. of rain. Like other float gages the cumulative inertia error inherent in gages of the tipping-bucket type is eliminated. Like the tipping-bucket gage it gives a fairly precise indication of the time of occurrence of high rainfall intensities. Water enough is left in the receiver to sustain the float, and a layer of kerosene oil is used to prevent evaporation. This gage is not yet on the general market but can be obtained, built to order.

Rain Gages on Board Ship.

The rainfall over the ocean is much less completely determined than that over the land. It is probably subject to much less local variation. Fairly reliable determination of the average rainfall for any latitude and longitude over the ocean can be determined from records made on board ships at sea.

Rain gages for this purpose are furnished by the British Meteorological Office, and the following description of the method of erecting rain gages on board ship is given in the Marine Observers' Handbook (see Fig. 12):

"The instrument is attached to an iron frame, Fig. a, by two bands (bb) which encircle the cylinder, two tubes (tt) forming the sides of the frame.

"A two-pronged fork of bar iron (pp) has an eye (e) formed in the bend of the bar, for use in securing an iron halyard block or gin (g) to the fork and the fork to the stay.

"In Fig. 12, b, the rain gage is shown attached to its frame.

"In the eyes (e'e') at the end of each prong of the fork a 1-in. steel-wire rope is spliced, to serve as guides to the gage, also as guys when necessary.

"The fork is lashed to the stay, at a suitable distance from mast or funnel, at a height of from 20 to 30 ft. above the deck; the two guides are rove through their respective tubes and set up to eyebolts or other suitable fixtures on deck, perpendicular.

"The rain gage is hoisted to the stay by a halyard, one end of which is seized to the lower cross-bar of the frame, the other end being rove through the block pendant from the eye of the fork,

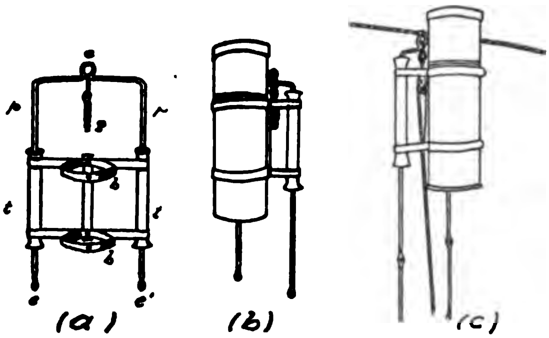


FIG. 12. METHOD OF SUPPORT OF A RAIN GAGE ON BOARD SHIP.
(a) Frame. (b) Rain Gage and Frame. (c) Rain Gage Hoisted to Stay.

and led to the deck. The operation resembles that of hoisting a masthead lamp; the prongs of the fork running into the tubes, which form the sides of the frame, in a similar manner.

"When the frame is hoisted close up to the stay, the rim of the gage will be above it; thus the instrument will have a free exposure, Fig. c.

"Should the gage require steadying when it is in its position and the guides are set up taut, the latter should be released, carried outward, and re-set up rather nearer the ship's side."

SHIELDED RAIN GAGES.

It was early discovered (Heberden, Westminster Abbey, 1769) that rain gages above the ground and unprotected caught less and less rainfall as the height of the gage increased. In 1811, Luke Howard showed by experiment with rain gages placed on buildings and compared with those placed on the ground that the difference was due to the action of the wind. This matter will be discussed in a subsequent paragraph.

In order to remedy this defect, where gages cannot be placed at ground level, the use of garnitures and shields around the mouth of a gage was suggested, first by Thomas Stevenson in 1841. Later, Joseph Henry, in 1853, recommended the use of a horizontal circular time plate, 4 in. or 5 in. wide, and surrounding the gage

funnel. The most successful of shields thus far devised is that invented by Prof. F. E. Nipher, of St. Louis, in 1878. Fig. 14 illustrates a gage equipped with a shield of the Nipher type. The deficiency of catch of an unprotected rain gage increases with the wind velocity, is greater in light than in heavy rains, and is greatest of all for dry snow.

Wild, in Russia, in 1885, devised a rectangular wooden enclosure of wicker work, which has been used quite extensively in Russia. The following table shows the percentage of rainfall as determined by protected gages, which was caught by gages in St. Petersburg between 1891 and 1894. Unprotected gages are compared with gages with the Nipher and Wild shields respectively.

	Ratio — *Unprotected* Nipher Jacket.		Ratio — *Unprotected* Wild Fence.	
Mean Wind Velocity..........	0–3 Meters per Sec.	7 or More Meters per Sec.	0–3 Meters per Sec.	7 or More Meters per Sec.
Dry snow..............	87%	40%	83%	31%
Wet snow..............	92%	80%	86%	80%
Light rain.............	92%	90%	85%	89%
Heavy rain............	99%	99%	99%	99%

(British Rainfall — 1906.)

In England the usual height of gage funnels is one foot above ground. In the United States, where snowfalls of two feet or more may occur, and on account of the likelihood of interference with ground or pit gages, it is customary to place the rain gage at somewhat greater height. Where a ground exposure is used, a height of funnel of 4½ ft. is convenient, and is about the least which will insure against interference by children and animals.

According to the instructions to observers of the British Rainfall Organization:

"*Site.* A rain gage should be placed on a level piece of ground, not upon a slope or a terrace, and certainly not upon a wall or roof. It should be at a distance from every object higher than itself, and should never be nearer to a wall or house than a dis-

tance equal to the height of that object, nor nearer to a growing shrub or tree than a distance equal to twice that height. Care should be taken to keep flowers or vegetables away from the gage for a distance of at least three feet all around. If a perfectly open site cannot be obtained, shelter is least harmful on the northwest, north and east: but the exposure to southwest and northeast should always be free. The height above sea-level should be determined, if possible, by leveling from the nearest bench mark. The approximate height may be easily ascertained in most cases by reference to the maps of the Ordnance Survey. A specific name should be selected by each observer for his station."

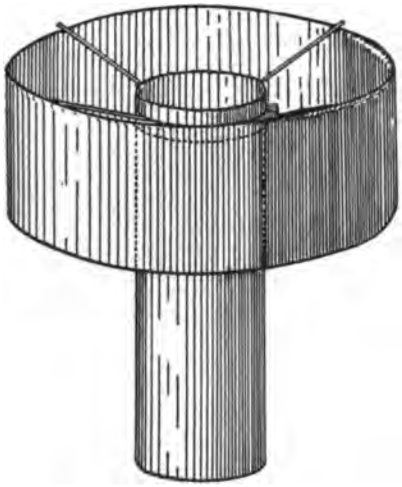


FIG. 13. CLOTH WIND SHIELD.

FIG. 14. SHIELDED SEASONAL SNOW GAGE.

"*Mountain and Moorland Sites.* Care should be taken that mountain and moorland gages are not unduly exposed to the sweep of the wind. A level patch of ground or a very slight hollow should be selected, and a turf wall, about 2 ft. high, surrounding the gage at a distance of from 6 to 10 ft. is recommended."

"*Height Above Ground.* The funnel of a rain gage should be set exactly level, and at a height of 1 ft. above ground. If the gage is surrounded by long grass, or likely to become so, the height may be as much as 1 ft. 6 in., but it should never be more." (British Rainfall — 1906.)

"If an elevated rain gage is surrounded by a fence or enclosure, the top of which is the same height as the mouth of the rain gage, and 2 or 3 ft. away from it, the disturbance produced by the wind is greatly reduced, and fairly accurate readings can be secured." (British Rainfall — 1910, page 75.)

The "pit gage" recommended by Symons, stands in an open field at the center of a slight depression of a yard or more in radius. The pit is so hollowed out and the earth is thrown up in a circular ridge on the outside of the pit that the mouth of the gage is on a level with or slightly below the rim of the pit.

Fig. 13 illustrates a rain-gage shield of much simpler construction than the Nipher shield. The results obtained with its use have not been reported. In the United States it is customary, where gages are placed at ground level, to select a location where there are low shrubs or fences having heights about equal to the height of the gage funnel above ground, and at a little distance from it. There should be no taller objects, such as a tree or building, nearer to the gage than a distance equal to the height of the object, or, preferably, at a distance not less than twice the height.

Snowfall Measurement.

The actual measurement of precipitation falling as snow involves so much more difficulty than the measurement of rain as to deserve some special consideration. While an ordinary overflow can of the ordinary Weather Bureau rain gage is commonly used to catch snow, the amount of which is determined in terms of equivalent water depth by methods already described, this procedure is far from satisfactory. As already pointed out, the deficiency in catch of a rain gage is much greater for snow than for rain. The effect of a combination of wind and snow on the catch of an ordinary rain-gage overflow can is shown by Fig. 15. In the storm in which this sketch was made, and which occurred December 26, 1913, at Albany, N. Y., the amount of precipitation as determined from the snow caught in the gage can was 0.43 in., whereas the actual precipitation as determined from a sample of the undrifted snow on level ground was 1.41 in.

To avoid errors of this kind, the United States Weather Bureau recommended that, in case of snowfall or windy days, "the true

quantity must be found if possible by measuring a section of the freshly fallen snow cut out by forcing the overflow mouth downward through the layer, and then slipping a thin board or sheet of metal underneath so as to separate and lift up the section of snow thus cut out." Needless to say, the sample should be taken in

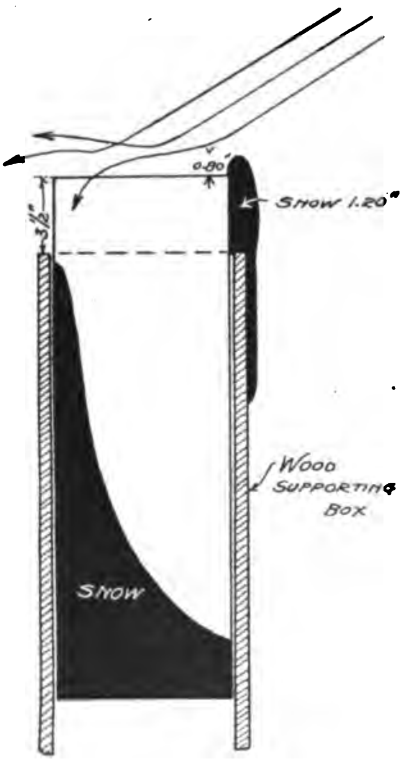


FIG. 15. ACTION OF SNOW OR RAIN GAGE.
Arrows show path of snowflakes.

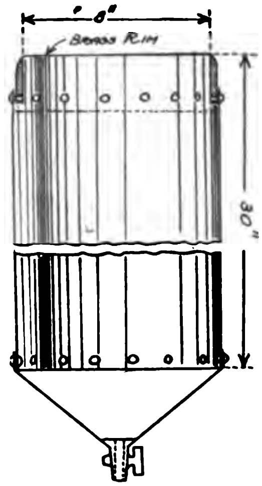


FIG. 16. SECTION OF FRESH SNOW SAMPLER.

a protected place where drifting does not occur. (Measurement of Precipitation, Instrument Division, U. S. Weather Bureau, Bulletin No. 13, p. 9.)

Modified methods and a special form of overflow can, for use in taking samples of snow on the ground, have been devised by the writer. The snow sampler is illustrated by Fig. 16.

A New Snow Sampler.

The edge of the galvanized rain-gage can is not sharp or stiff enough to retain its circular form with certainty when thrust down through deep snow. A special can with a reinforced cutting edge chamfered on the outside and inserted in the mouth of the can will reduce the friction and facilitate obtaining an accurate sample. This can should have a brass drain cock at the closed end, this cock to be opened when taking a sample so as to permit air to escape and prevent the snow being forced out while taking a deep sample by the compression of air in the can. Another advantage of a can with a drain cock is that when the sample is melted with hot water it can be drained out, thus avoiding the difficulty of pouring water from the large can into the brass tube without spilling. The closed end should be preferably made funnel-shaped, with a large, straight-way water cock similar to the bottom of the Friez tipping rain gage. A tight-fitting cover for the open end is also desirable. This may be placed on the can immediately after the hot water is added, and the can set in a warm place, if necessary, to complete the melting of the snow. Cover will prevent appreciable evaporation loss.

This snow sampler can be used either for freshly fallen or accumulated snow. It is also intended to replace the ordinary overflow can of the rain gage, but when so used the bottom ring of the gage funnel must be enlarged to fit over the brass cutting edge of the sampler. When used as an overflow, the drain cock prevents loss by spilling, and is a great convenience. The conical base reduces danger of breakage by freezing.

Select a level space surrounded by shrubs or sparse trees. The open space or clearing should be 50 to 100 ft. or more in diameter, depending on the height of the shrubs or trees. As a rule, snow will not drift nor be blown away near the middle of such a park or open space. In selecting the spot for snow measurement it is preferable to observe the conditions for a year in advance of its use. When snow falls at an angle, as it commonly does, a tree shadows the ground for some distance to the leeward and prevents the full depth of snow from reaching the ground. The spot chosen for making measurements must be sufficiently remote from all trees to avoid an error from this source.

Before the first snowfall, place on the ground a sheet of very thin board — plaster board or beaver board answers well. On the upper surface there should be secured by thumb tacks at the corners a sheet of white cloth with a rough surface — white flannel is good. The position of the board may be marked by two or three stiff wires stuck into the ground at a little distance from the board. When the first snowfall comes, a special snow can, described above, may be inverted over the cloth and pressed down firmly, rotating it slowly as it is pressed down. Then the remaining snow should be brushed off from the cloth, the board lifted, at the same time lifting and inverting the can with the board over its mouth. Having shaken the snow down into the galvanized can, the sample may be reduced to slush or water by adding a measured volume of hot water and then measuring in the brass rain-gage tube in the usual manner used for rainfall and deducting the equivalent of the hot water added.

After a measurement, the flannel cloth is, if necessary, dried, retacked on the snow board, and the snow board placed on the surface of the newly fallen snow where the snow is undisturbed, the board being pressed down just sufficiently so that the cloth surface is flush with the snow surface. The snow board should be inspected every day whether it snows or not, so as to keep its surface flush with the snow surface at all times.

The use of a cloth is twofold. (1) It provides a surface with friction conditions much more closely resembling those of snow than could be obtained by the use of the board alone. (2) It provides a surface as nearly as can readily be obtained, equivalent to a snow surface in its capacity to absorb and radiate heat, and so prevents loss by melting when snow falls in relatively warm air.

Measurement of Accumulated Snow.

The water equivalent of accumulated snow on the ground at any given date is an important factor in relation to the water supply available to fill reservoirs, provide water for public usage, or irrigation, or to produce floods. In order to obtain data from which the available water supply of the coming spring may be estimated in advance, snow surveys have been extensively carried

out, especially in the Rocky Mountain region, during the past few years.

Methods of the accurate measurement of snow in the mountains where it sometimes accumulates to a depth of 20 ft. or more have been developed, but no attempt will be made here to treat those methods in detail. It is not a difficult matter, with proper apparatus, to keep a record, say, once a week of the water equivalent

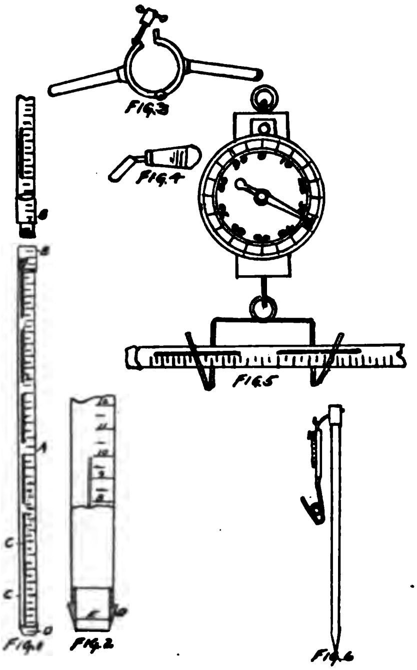


FIG. 17. MT. ROSE SNOW SAMPLER.

of accumulated snow on the ground; and such a record, in conjunction with an ordinary record of rainfall and snow, will afford a valuable check on the latter, and furnish useful information besides.

Among the earliest records of accumulated snow and its water equivalent kept in the United States were those kept by Charles A. Mixer, at Rumford Falls, Me., in 1901 to 1903, and by the writer

at Utica, N. Y., in 1903 and 1904. Apparatus for snow sampling and weighing developed at Utica formed a pattern for subsequent improved apparatus of the United States Weather Bureau. Figs. 17 and 18 illustrate snow-sampling tubes, measuring staffs, and weighing scales of the most improved type.

Before leaving this subject, it may be noted that there is a popular opinion that 1 in. of rain is equivalent to 10 in. of snow, and a method of estimating precipitation in the form of snow,

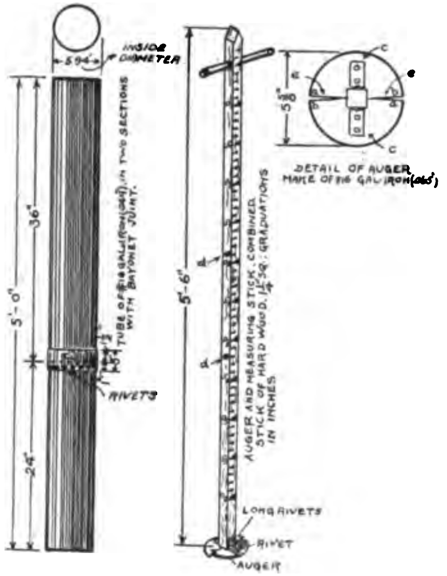


FIG. 18. THE KADEL SNOW SAMPLER.

consisting of first measuring the snow and then dividing the depth by 10 in., is sometimes used. This method is unreliable. The water equivalent of freshly fallen snow varies to a considerable degree. It may range from 1 in. of water to 6 in. of snow, for moist or dense snow, when the air temperature is around the freezing point, to 1 in. of water for 10 or 12 in. of snow at lower temperature. Furthermore, these rules do not apply at all to the accumulated snow, the water equivalent and density of which nearly always increases as winter advances. Commonly, deep

snow lying on the ground for some time will have a density of 0.25 to 0.40, or a water equivalent of 1 in. for 2½ to 4 in. of snow.

Rainfall Duration Records.

Reliable records of rainfall duration are much needed for use in various hydrologic problems, and more attention should be given to the subject of rainfall duration. Records of rainfall duration can, however, generally only be obtained by the use of recording gages, and these for reasons already pointed out are not wholly satisfactory for determining the duration of very light rainfall.

For the purpose of accurately determining rainfall duration, an instrument, which I think may be properly termed an "ombroscope," has been devised by Dr. O. L. Fassig. In this instrument, a sheet of sensitized paper is drawn slowly past an opening by means of clockwork. When it rains, however lightly, some of the drops are quite certain to strike the opening and produce blotches on the sensitized paper, making an autographic record, a sample of which is shown in Fig. 19.

Reading and Inspection of Rain Gages.

The rule of the British Rainfall Organization is that readings should be taken at 9 A.M. In the United States there is no uniform practice as to the time of reading rain gages. The rule for coöperative observers is that the gage should be read at 8 P.M., 75th meridian time — however, many voluntary observers apparently read their rain gages at 5 or 6 P.M. At the regular Weather Bureau stations where recording gages are maintained, the published daily rainfall for twenty-four hours is from midnight to midnight. At many coöperative stations maintained by waterworks officials and others, rain gages are read in the morning. This diversity of practice leads to some inconvenience, where, as is often the case, it is desired to compare the amount of rain in the same storm or on the same day at different near-by stations.

It seems desirable to conform as closely as possible to the rule that the rainfall reported for a given day should be for the period from midnight to midnight. Readings taken in the evening,

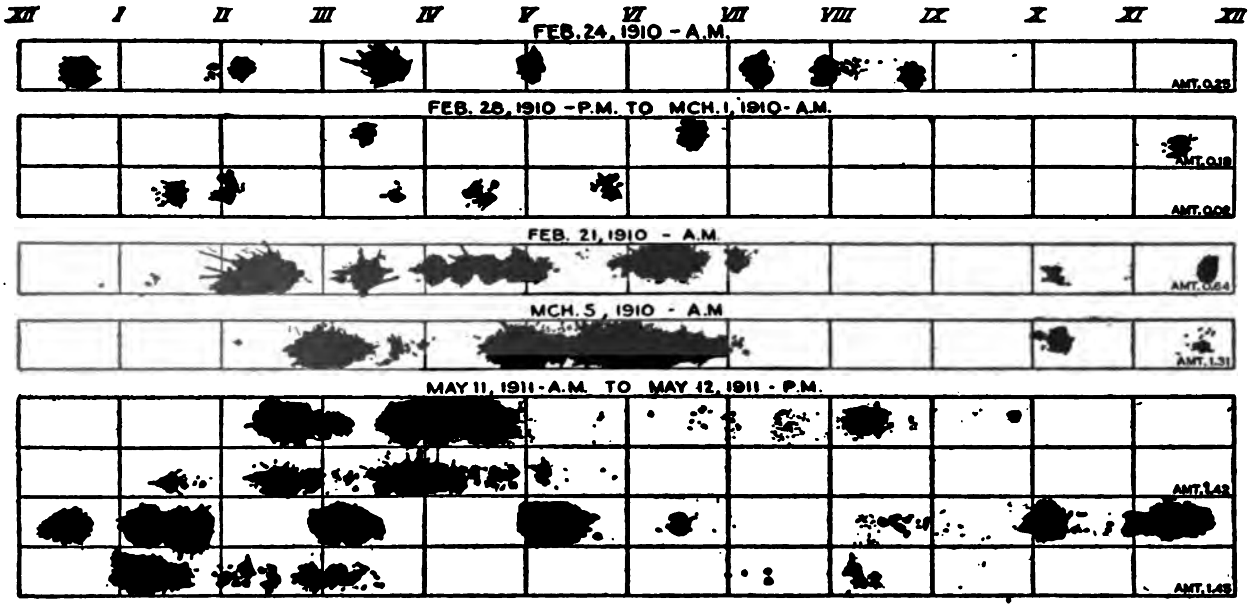


Fig. 19. Rain Autograph or Automatic Record showing Duration and Intensity of Rainfall. (Fassig.)

especially those taken at eight o'clock, will compare better with midnight readings, as a rule, than those taken on the following morning, and there is also less liability of confusion regarding the actual day on which the greater portion of rain fell.

On the other hand, evening readings are subject to the objection that throughout the winter period they must be taken after dark. It is not always the rule but it is always desirable that a rainfall observer should inspect his gage at a regular hour every day, whether any rain falls or not. If this is not done, some slight showers are pretty certain to be missed, or included in the next subsequent heavy rain.

With regard to accuracy there is a great difference in observers. An observer should be instructed to report the measured amount of rain to the nearest hundredth inch shown on the cedar measuring stick. If not specially so instructed, the observer is likely to always report the number of hundredths wholly covered by the wetted portion of the stick. In this way the records will contain a small but appreciable error, since, for example, all rainfalls between 1.50 and 1.51 in. will be reported as 1.50. If there are 140 rainfalls in the year, the annual error will amount to a total of .7 in.

One of the easiest ways to determine the care with which an observer is keeping his records of rainfall is to notice the frequency with which he records traces. At any given location, the number of traces of rain (meaning by trace a rainfall less than 1/100 in.) bears a fairly constant ratio to the number of rainfall days. Some observers will be found to omit traces altogether, others record any small amount of rain a trace, and there will be a notable deficiency of measurements of precisely 1/100 or 2/100 in. This condition of affairs invites a strong suspicion that the observer does not read the gage for light rainfall, but simply records a trace. The above remarks point to the necessity of regular and careful inspection of rain gages.

It is also greatly to be lamented that Congress has not seen fit hitherto to provide funds for the regular inspection by Weather Bureau officials of voluntary and coöperative rainfall stations. Pending such provision, those interested in accurate rainfall records may render a valuable service by taking the trouble to

examine any Weather Bureau rain gage they encounter, noting the setting and condition of the gage, interrogate the observer as to his methods, and report the result to the Weather Bureau officials. Regular inspection of rain gages maintained by water-works organizations is equally needful.

A rain gage should always be initially located, or any change of location made, by an experienced man. If a change of location is necessary, it is very desirable that a gage should be maintained in the original location, and another one in the new location, and the records kept simultaneously for one or two years. Continuity of rainfall records greatly facilitates their use. A slight change in the location of a gage may or may not materially affect the results. This fact can be determined by a comparison of gages running in parallel.

Freedom from interruption is also of great importance. Any user of rainfall records knows how troublesome it is to find missing months or years just at the critical time in an important rainfall record. Such omissions can generally be supplied in a fairly reliable manner by methods which need not here be described. A patchwork record is, however, never quite as satisfactory as one that is complete and homogeneous. It is often desirable to instruct two observers at each location, one to act as a substitute in case the other is unable to take the readings for any reason. It may be remarked in passing that women very often make better rainfall observers than men.

Best Size and Type of Rain Gage.

The rain gages now in general use are either 8 or 5 in. in diameter. The Friez recording gage has a 10.5-in. funnel. Gages with 3-in. funnels were formerly sometimes used. The results of some of the more recent experiments as to the relative amount of rain caught by gages of different sizes and types are described in the following paragraphs.

Hellman's Experiments.

The results of Hellman's experiments in 1886 and 1887 are shown in the accompanying tables Nos. 1 and 2. The gages were

TABLE 1.

Hellman's Comparison of Rain Gages.

No.	Name.	Actual Diameter.		Catch June, 1886 — March, 1887.		Per Cent. of Gage No. 11.
		M.M.	Inches.	M.M.	Inches.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Von Bezold.........	252.19	9.936	279.8	11.024	96.5
2	Von Bezold.........	252.30	9.941	280.3	11.044	96.7
3	Hellman............	252.13	9.934	287.7	11.335	99.2
4	Hellman............	224.85	8.859	285.9	11.264	98.6
5	Hellman............	195.20	7.691	285.6	11.253	98.5
6	Hellman............	159.65	6.290	288.0	11.374	99.3
7	Hellman (Conical)...	159.74	6.294	285.4	11.245	98.4
8	Hellman	112.38	4.428	281.4	11.087	97.0
9	Assman.............	252.30	9.941	283.4	11.166	97.7
10	Assman (Conical)....	252.62	9.953	285.6	11.253	98.5
11	Hattinger...........	113.55	4.474	290.0	11.426	100.0

TABLE 2.

Numbers of Gages giving Maximum and Minimum in each Month and Range of Difference in Per Cent. of Catch by Gage No. 11.

Month.	Max.	Min.	Per Cent.
June, 1886.......	No. 11	1	5.6
July.............	7	8 and 9	4.5
August...........	11	2 and 8	6.1
September........	3 and 4	1 and 2	2.3
October..........	11	1	6.6
November...... ..	11	1 and 7	6.1
December, 1886...	9	1 and 2	7.2
January, 1887....	8 and 11	9	11.1
February.........	7 and 11	9 and 10	4.1
March, 1887......	6	8	4.3
Total........	11	1	3.5

set on level ground in a circle $1\frac{1}{2}$ meters between gages, with the gage funnels all $1\frac{1}{4}$ meters (4.10 ft.) above ground. They were surrounded by low trees and shrubs at a distance. They were all cylindrical gages except Nos. 7 and 9, which had conical funnels. The Von Bezold gage had a splayed rim flanging downward and outward from the edge of the funnel on the outside. The gage of smallest diameter, except one, gave the largest catch; and the smallest gage caught more than the largest. The range of error was largest in the winter months.

The Philadelphia Rain-Gage Experiments.

In connection with the Bureau of Water, Philadelphia, an automatic gage having a collector $22\frac{5}{8}$ in. in diameter was used. As there was diversity between the results shown by different gages, experiments were carried out to determine the effect, if any, of variation in diameter. John E. Codman. (Report, Bureau of Water, Philadelphia, 1891, p. 301.)

The following tabulation contains the results of these experiments on similar gages of various diameters exposed at the same height.

BRASS KNIFE-EDGE RIM GAGES.

Diameter, inches	1	2	4	5	6	8	12	24
Catch, relative to 24-in. gage	93	96	100	99	102	102	100	100
Catch, relative to 8-in. gage	91	94	98	97	100	100	98	98

If it is assumed that a gage cannot catch more than true amount unless from outside causes, these data seem to indicate that 8 in. is the optimum size.

The Ithaca Rain-Gage Experiments.

Experiments on different types of gages hitherto used in the United States were made at Ithaca, N. Y., by Alfred M. Wilson, during the years 1908, 1909, and 1910, for the New York State Conservation Commission. The gages used were of the Smithsonian, Fuertes, and DeWitt conical pattern, and they were com-

pared with a standard United States Weather Bureau gage. These gages are illustrated by the accompanying Figs. 2, 3, and 4. One each of these gages was placed on the ground and one of each at an elevation of 10 ft. above ground. The experiments were carried on throughout the open season only. The results, expressed in inches and in percentages of the catch by the United States Weather Bureau gage, are summarized in the accompanying table No. 3.

TABLE 3.

ITHACA EXPERIMENTS ON RAIN GAGES.

Period.	U. S. Weather Bureau 8-in. Gage.	On Ground.			10 Ft. above Ground.		
		Smithsonian.	Fuertes.	DeWitt Conical.	Smithsonian.	Fuertes.	DeWitt Conical.
Total Catch in Inches.							
May — Nov., 1908..	18.84	19.48	19.66	18.75	20.08	19.97	18.03
Apr. — Oct., 1909...	18.68	18.68	18.67	18.16	19.40	19.17	18.20
Apr. — Oct., 1910...	20.74	20.11	20.86	19.67	21.14	21.81	20.16
Total..........	58.26	58.27	59.18	56.58	60.62	60.95	56.39
Percentages of U. S. Weather Bureau Gage.							
May — Nov., 1908..	100.0	103.4	104.4	99.5	106.6	106.0	95.7
Apr. — Oct., 1909...	100.0	100.0	99.9	97.2	103.9	102.6	97.4
Apr. — Oct., 1910...	100.0	97.0	100.6	94.8	101.9	105.2	97.2
Mean..........	100.0	100.0	101.6	97.1	104.1	104.6	96.8

These experiments indicate that the three early types of rain gages experimented upon give results within 5 per cent. of those obtained from a Weather Bureau gage. If the assumption often

made, that a gage cannot catch more than the true amount of precipitation, were correct, then it would appear that the Smithsonian and Fuertes gages must be superior to the Weather Bureau gage. This conclusion is not necessarily correct. It is undoubtedly true that the eddies caused by the wind striking a rain gage, at least a cylindrical gage, tend to blow rain, and especially snow, away from the gage; but it is also true that if wind action causes precipitation less than the true amount in one place, the deficiency there must be distributed as excess over some other area, and eddies around the outside of a gage may possibly cause an excess catch of rain in the gage itself in the case of conical or other non-cylindrical gages.

Whether or not the conical gages, here experimented upon, operated so as to carry into the gage rain in excess of the true amount cannot be stated.

Rothamsted Rain-Gage Experiments.

For several years, 5-in. and 8-in. rain gages have been maintained in conjunction with a gage of one-thousand-acre area at Rothamsted experiment station in England. The results are shown in table No. 4. Taking the catch of the one-thousand-acre gage as unity, the relative amounts are as follows:

5-in. gage	0.967
8-in. gage	0.948
1 000-acre gage	1.000

Considering all the experiments cited, it cannot be definitely stated which is the best type or size of gage. There are, however, good reasons for the preference of the gage of cylindrical form. And when gages of similar form are compared it appears very probable that the one giving the largest catch is most nearly correct. Similar cylindrical gages were compared in the Philadelphia experiments, and these indicate that a diameter of 8 inches is to be preferred; while the Rothamsted and Ithaca experiments and those of Hellman afford some rather strong evidence that an 8-in. cylindrical gage shows about 5 per cent. less than the true precipitation.

The experiments relate mostly to the catch of rain, and, as elsewhere pointed out, much larger errors may occur in the catch of snow. The writer is not ready to accept definitely the conclusion that an 8-in. cylindrical gage catches 5 per cent. less than the true amount of rain when properly exposed, but in view of the evidence presented the matter seems worthy of still further careful

TABLE 4.

COMPARISON OF ROTHAMSTED RAIN GAGES.

Water Year — (September — August, inclusive.)

Year.	5-In. Gage.	8-In. Gage.	$\frac{1}{1\,000}$ Acre Gage.
(1)	(2)	(3)	(4)
1881–2	31.66	30.35	32.31
1882–3	33.69	32.98	34.71
1883–4	25.29	24.44	25.77
1884–5	25.90	25.42	26.78
1885–6	29.46	29.08	31.02
1886–7	22.63	22.29	23.61
1887–8	29.11	28.82	30.50
1888–9	28.79	28.57	30.09
1889–90	26.73	26.30	27.43
Total	253.26	248.25	262.22

experimentation. In the Ithaca and Hellman experiments the gages were not shielded, nor were they at ground level. In the Rothamsted experiments the small gages were one foot above ground. Dr. H. R. Mill, and others in England, have found that a rain gage catches about one per cent. less than the true rainfall for each foot of height of the funnel above ground. Accordingly, all the gages in the Ithaca and Hellman experiments probably show less than the true amount of rainfall; but since all gages were at the same height, the reason why some caught more than others remains unexplained.

TABLE 5.

Comparative Yearly Precipitation Caught by Gages at Various Heights above Ground, Royal Observatory, Greenwich, England.

	Self-Recording Gage.	Second Gage.	Roof of Octagon Room.	Roof of Magnet House.	Roof of Thermometer Shed.	Ground Gages.		
						Magnetic Pavilion.	Observatory Grounds. (1)	Observatory Grounds. (2)
Ht. above ground........	50.67	50.67	38.33	21.5	10.0	0.42	0.42	0.42
El. above tide...........	205.	205.	193.	176.	165.	155.	155.	155.
1903...........	22.77	23.69	28.75	33.00	35.15	35.54	35.50	35.62
1904...........	10.95	12.72	16.86	18.90	20.43	20.66	20.33	20.67
1905...........	12.77	13.25	18.42	20.62	22.87	23.02	22.82	23.40
1906...........	13.07	13.52	18.66	21.37	23.70	24.74	23.81	....
1907...........	13.33*	13.74*	17.80	19.40	21.47	22.25	21.58	....
1908...........	13.76	15.53	19.09	20.84	22.78	23.78	22.74	23.42
1909...........	15.07*	15.76†	20.33	22.92	25.03	25.71	24.83	25.07
Mean...........	14.53	15.46	19.99	22.44	24.49	25.24	24.52	25.63

Ratio to Mean of Ground Gages.

	Self-Recording Gage.	Second Gage.	Roof of Octagon Room.	Roof of Magnet House.	Roof of Thermometer Shed.	Magnetic Pavilion.	Observatory Grounds. (1)	Observatory Grounds. (2)
1903...........	.641	.675	.809	.928	.989			
1904...........	.533	.619	.820	.920	.994			
1905...........	.553	.574	.798	.893	.991			
1906...........	.539	.557	.769	.880	.976			
1907...........	.608	.627	.812	.885	.980			
1908...........	.590	.666	.815	.894	.976			
1909...........	.598	.625	.807	.909	.993			
Mean...........	.580	.620	.804	.901	.986			

* Three missing months interpolated.

† One missing month interpolated.

TABLE 6.

JOHN E. CODMAN'S PHILADELPHIA EXPERIMENTS ON THE CATCH OF RAIN GAGES AT VARIOUS ALTITUDES.

Height of Gage — Feet.	0	5	10	15	25	50	Prevailing Wind from			
Side of Mast.		S.	W.	N.	E.	Above and S. E.				
Year.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	NE.	SE.	SW.	NW.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)			
Apr. — Dec., '91	30.52	29.07	30.41	29.96	30.70	29.79	29	15	13	11
Year 1892	39.35	35.41	36.90	36.70	35.65	37.46	43	13	16	22
Mar. — Dec., '93	35.47	33.16	33.23	34.83	32.68	31.68	37	13	17	17
Mar. — Dec., '94	41.58	39.75	39.79	40.55	39.63	38.10	42	26	19	11
Total	146.92	137.39	140.33	142.04	138.66	137.03				

Effect of Wind and Exposure on Accuracy of Rain Gages.

This matter has already been referred to, but may properly be presented in somewhat greater detail.

The table No. 5 shows the results of a comparison of several gages at different altitudes for a period of seven years, from observation at the Royal Observatory, Greenwich, England. These data show a consistent decrease in catch with increased altitudes. The results also show slight difference in the catch of identical gages at ground level. The results of a series of observations with rain gages at different altitudes at Philadelphia are contained in table No. 6. Here again is found a somewhat irregular decrease in the amount of catch as the height above ground is increased. The experiments were conducted by Mr. John E. Codman, and the results are contained in the reports of the Bureau of Water at Philadelphia for the years 1891 to 1895 inclusive.

The gages were freely projected from a common mast on radial arms 10 ft. in length and on different sides of the mast, as indicated in the table. The mast was only 8 in. in diameter, yet rain gages on the windward side caught appreciably more than those on the leeward side.

The following discussion of the effect of wind on the catch of rain gages is adapted from a paper by Dr. Cleveland Abbe (Bulletin No. 7, U. S. Weather Bureau, Forest Influences):

"In the case of ordinary rainfalls we invariably have the air full of large and small drops, including the finer particles that constitute a drizzling mist and the fragments of drops that are broken up by spattering. All these are descending with various velocities, which, according to Stokes, depend on their size and density and the viscous resistance of the air; the particles of hail descend even faster than drops of water and the flakes of snow descend slower than ordinary drops. Now, when the wind strikes an obstacle the deflected currents on all sides of the obstacle move past the latter more rapidly; therefore the open mouth of the rain gage has above it an invisible layer of air whose horizontal motion is more rapid than that of the wind a little distance higher up. Of the falling raindrops the larger ones may descend with a rapidity sufficient to penetrate this swiftly moving layer, but the slower falling drops will be carried over to the leeward side of the gage, and failing to enter it will miss being counted as rainfall, although they go on the ground nearby. . . .

"The action of the wind in blowing the precipitation over to the leeward of the gage depends on velocity rather than on the square of the velocity of the wind and of the raindrop, and it is aggravated by the formation of whirls or eddies within the gage itself by reason of which light and dry snowflakes are even whirled out of the gage after being once caught in it. Similar remarks apply to the rainfall on the top of a large square building with a flat or depressed roof; not only does the top as a whole receive less than an equal area at the ground, but the distribution of rainfall on the roof is such that the least rain falls on the windward portion and the most on the portion to leeward, while somewhere on the roof will be found a region whose average rainfall coincides with that on the ground. But the location of this region will vary with the direction and strength of the wind and the quality of the precipitation, so that we have but little assurance that any single rain gage on the roof will represent the rainfall on the ground. . . .

"If properly protected from the wind, a gage placed at any altitude below the cloud level will unquestionably catch as much rain as one placed at the ground surface — in fact, if there is any difference, the catch at higher altitudes should in most cases be slightly greater, since the ordinary conditions while rain is falling, especially if there is wind, will generally permit of slight evaporation from the falling drops. . . .

"However, it is increasingly difficult to shield a gage against wind action as the altitude increases, since experiments at Philadelphia and elsewhere have shown that the shield itself, if of improper form, may, by forming eddies, decrease the amount of rain entering the gage."

United States Weather Bureau rain gages are commonly placed on roofs of buildings, especially in cities.

A. J. Henry ("Rainfall of United States." Report of Chief of Weather Bureau 1898, pp. 318–19) notes the larger catch observed near the ground compared with the Weather Bureau gages on buildings as observed at St. Louis and Philadelphia, and also the apparently contradictory comparison of the Lower Broadway gage, 150 ft. above the ground, and the Central Park gage, in New York.

Henry says:

"It does not seem possible to avoid the conclusion that the absolute amount of precipitation as registered by the Weather Bureau gages, when placed on high buildings, falls short of the true amount by quantities varying from 5 to 10 per cent. of the true rainfall."

McAdie (Aërography, p. 210) concludes that the catch of rain gages exposed on the roofs of tall buildings in cities where they are almost inevitably subject to wind eddies is too low. He estimates that the recorded rainfall in most American cities where these conditions exist as differing by 30 to 40 per cent. from the amount which could be collected by a gage on the ground. The author does not concur in this conclusion.

There are some cities, as Providence, for example, where such differences certainly exist, but in many other places with rain gages on roofs there is no evidence of deficiency.

From an analysis of 23 records in various places covering an aggregate of one hundred and thirty-five years at various places, showing the relation of the catch of gages at various altitudes to a normal pit gage, Abbe deduced the formula:

$$\text{Percentage deficiency} = 3.32 \sqrt{H}$$

where H is the height of gage above ground in feet.

This gives very good agreement with the observed values.

It relates to relatively unprotected gages, — not to gages shielded by the parapet walls of buildings, as are most United States Weather Bureau gages.

In general, if a gage is under suspicion from wind action, it is best to determine the necessary correction from direct observation by Abbe's method described below. This requires the use of a second gage for comparison.

Assuming that the effect of wind is proportional to its velocity and that the velocity varies as the square root of the altitude, then for any single storm,—

$$c_1 = 1 - xH_1R$$
$$c_2 = 1 - xH_2R$$

Where c_1 and c_2 are the actual amounts caught by gages at heights H_1 and H_2, R is the true precipitation at ground level, and x is an unknown wind factor — eliminating x and solving for R, we have —

$$R = c_1 + N\,(c_1 - c_2),$$

$$\text{where } \frac{1}{N} = \sqrt{\frac{H_2}{H_1}} - 1.$$

The following table gives values of the factor N.

TABLE 7.

Abbe's Correction Factor N for Unprotected Rain Gages.

$\frac{H_2}{H_1}$	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
1	00	20.488	10.485	7.133	5.458	4.450	3.775	3.291	2.927	2.643	2.414
2	2.414	2.227	2.069	1.936	1.821	1.721	1.633	1.554	1.485	1.423	1.366
3	1.366	1.315	1.268	1.225	1.184	1.148	1.114	1.083	1.053	1.026	1.000
4	1.000	.976	.954	.931	.911	.892	.873	.856	.839	.824	.809
5	.809	.795	.781	.768	.755	.743	.732	.721	.710	.700	.690
6	.690	.680	.671	.662	.654	.645	.637	.630	.622	.615	.608
7	.608	.601	.594	.588	.581	.575	.569	.563	.558	.552	.547
8	.547	.542	.536	.532	.527	.522	.517	.513	.509	.504	.500
9	.500	.496	.492	.488	.484	.480	.477	.473	.469	.466	.463
10	.463	.459	.456	.453	.449	.446	.443	.440	.437	.434	.432

There is another aspect of the relation of air currents to rainfall measurement. It has to do with the general location and topographic surroundings of the rain gage rather than with the details of exposure of the gage.

In any given locality the prevailing rain-bearing winds usually come from some particular quadrant. In New England and eastern United States generally, the direction of wind during rain usually ranges from east or southeast to southwest. A hill, large building, grove, slope, or valley may produce local eddies or currents in rain-bearing winds so that the rain over a particular small space may be constantly less than or greater than the true amount in almost every storm. As a rule, an ascending air current at the surface will prevent the full amount of rain reaching the ground. An eddy with a vertical axis will often prevent the full amount of rain reaching the ground in its interior, but will deposit more than the true amount around its circumference. An eddy with a horizontal axis will often prevent the full amount of rain reaching the ground on the ascending side and will precipitate more than the true amount on the descending side.

The following table illustrates differences of this kind:

TABLE 8.

COMPARISON OF THREE RAIN GAGES, HORTON HYDROLOGIC LABORATORY.
August — September, 1918.

Date.	Tipping Bucket No. 1.	Erwin's No. 2.	West No. 3.
(1)	(2)	(3)	(4)
August 5	.55	.52	.59
7	.11	.13	.13
8	.01	.01	.01
9	.03	.04	.04
10	.27	.28	.28
11	.49	.47	.47
15	.15	.15	.15
25	1.50	1.48	1.60
27	.01	.01	.01
29	.12	.10	.12
30	.25	.25	.28
September 1	1.33	1.21	1.36
6	.11	.11	.13
7	.01	.01	.02
9	.06	.06	.06
12	.03	.02	.03
13	.58	.54	.62
14	.09	.09	.09
16	.01	.01	.01
17	.06	.06	.06
19	.63	.65	.66
20	.11	.12	.13
21	.81	.83	.90
24	.08	.08	.09
25	.03	.02	..
26	1.13	1.10	1.21
27	.62	.62	.70

Note: Readings taken at 7 A.M.

The three gages referred to are located at the writer's laboratory near Albany.

No. 1 is a Friez recording gage near the crest of a hill on the north side of a deep ravine. Nos. 2 and 3 are standard Weather

Bureau 8-in. gages. No. 3 is located about 500 ft. west of No. 1 on low, gently sloping ground, 50 ft. north of the border of a mill pond. No. 2 is located about midway between the others but on the south side of the ravine, opposite the foot of the pond and south of a grove of large hemlocks which border the south side of the ravine. The gages were all read at the same time and by the same observer, and are all at a height of about 3.5 to 4.5 ft. above ground. No. 3 gage shows, however, a greater catch than the others in the majority of cases.

If a gage is on level ground, remote from trees or buildings, it will usually be subject to somewhat severe wind action, and usually precautions are necessary to provide a proper exposure and shield the gage. If the ground is generally rough or rolling, or the gage is in a built-up district, the wind action may be less severe, but an intelligent and careful study of the situation is necessary to select a location such as to avoid local eddies. No very general or definite rules can be given as to the selection of a gage exposure in the latter case. Good judgment, preferably trained by experience, must be depended upon to afford the best solution in each instance. In studying a situation of this kind, the prevailing direction from which rain-bearing winds will come and the probable effect of irregularities of the ground, or of trees or buildings, in producing eddies, should be carefully studied. In general, a gage should not be placed either in the crest of or in the lee of a ridge running at right angles to the direction of rain-bearing winds.

Errors of Rainfall Measurements.

The usual errors to which rainfall records are subject include, —

1. Observation errors, personal equation, and mistakes.
2. Instrumental or ratio error.
3. Errors due to evaporation.
4. Errors due to inclination of the gage funnel.
5. Wind or exposure error.
6. Location error.

Observational Errors.

The most usual observation error arises from recording the nearest hundredth inch less than the true amount, and from counting as traces all quantities less than .01 inch. If the observer will follow the rule of recording the nearest hundredth inch, whether greater or less than the true amount, and of counting as .01 inch any quantity greater than 0.005 in. and less than 0.015 in., this error will be wholly obviated. As to mistakes, — those of excess are apparently as likely to occur as those of deficiency.

Instrumental Errors.

In the Standard Weather Bureau Rain Gage the cross-sectional area of the measuring tube, when containing the cedar gage stick, should be precisely 1/10 of the area of the gage funnel. If the ratio of these areas is not precisely one to ten, an accumulative error in the records will result. Such a condition is sometimes found, especially in old gages, due to bending or battering the rain-gage funnel. A similar error will result if the measuring stick is not correctly graduated.

If the diameter of the measuring tube and the graduation of the measuring stick are correct, but the rain-gage funnel is too large or too small, then the error in the result will be

$$\text{Error} = \frac{dA}{A} = \frac{2\pi r dr}{\pi r^2} = \frac{2dr}{r}.$$

When A and r are the true area and radius and dA and dr the error in area or radius, then for $r = 4$ in. for a diameter of 8 in.:

If $dr = 0.01$ in.,	error $= 0.0025$
0.02	0.005
0.03	0.0075
0.04	0.01
0.05	0.0125
0.10	0.05

Evaporation Loss.

The effect of evaporation is to make the measured less than the true precipitation. The evaporation loss is of two kinds:

1st. From the water contained in the inner gage tube.

2d. Water remaining on the inner surface of the gage funnel after the rain has ceased.

Evaporation from the inner tube takes place from the time rain begins until the time of measurement. The average time from the end of the rain until the measurement is made is twelve hours, and the average duration of rain on a rainfall day is commonly from three to five hours. The average time during which evaporation occurs may be taken as fourteen hours per rainfall day. The average rate of evaporation on rainfall days, as shown by numerous experiments, is about three fourths the average rate of evaporation for all days at the same place and season of the year.

In a case of a United States Weather Bureau rain gage, vapor can escape only from the $\frac{5}{8}$-in. orifice in the gage funnel. An experiment by the writer showed that with 10 in. of water in the inner tube of a Weather Bureau rain gage there was a loss of only 1/10 in. actual depth, equivalent to .01 in. depth of rainfall, for a period of seven days, with a constant temperature of about 70 degrees. At this rate the total loss for a year of 140 rainfall days at fourteen hours per day would be only about 0.12 in. There would probably be but few instances when this loss would cause the observer to record an amount .01 in. less than would have been recorded if no evaporation took place. The loss from this source is negligible.

The drops and film of water remaining in the funnel after the end of the rain and after all the water which will drain out has entered the gage, were found by the writer to have a weight of about 1/10 oz. This is equivalent to a depth of 0.0034 in. of rain. This for one hundred showers a year would be equivalent to 0.34 in. This loss does not occur in the measurement of snow by the usual methods. Here, again, there would be but few instances when effect of this loss would cause the observer to record an amount .01 in. less than the true amount.

Inclination Errors.

Rain gages not regularly inspected are sometimes found standing with their funnels exposed at an angle to the horizontal. This angle may be as much as ten or fifteen degrees. If the rain falls

vertically an inclined gage always catches less than the true amount. If a is the angle of the gage to the horizontal, the ratio of the amount caught to the true amount, in this case, will be as $\cos a$ to one. The error for various inclinations is as follows:

5 degrees.........	.4 per cent.
10 degrees........	1.5 per cent.
15 degrees........	3.4 per cent.

Rain ordinarily falls at an angle to the vertical of about one or two degrees for each mile per hour, wind velocity; the larger angle-wind ratios occur with small raindrops. The effect of inclination of a rain gage depends on the direction in which it is inclined relative to the direction of the rain-bearing wind. If the inclination of the gage is toward the wind and is less than twice the inclination of the rain, the gage will catch more than the true amount. If the gage is inclined away from the wind it will catch less than the amount for a horizontal gage. In a more general case where the rain comes with a wind not blowing parallel to but at a horizontal angle to the direction of the slope of the gage, let s be the angle of slope of the plane of the gage rim in the direction of the wind, s being negative if the gage is inclined away from the wind. Let b be the horizontal angle between the wind direction and the direction of the slope of the rain gage; then, from a simple geometrical construction, it can be shown that —

$$\tan s = \tan a \cos b.$$

Let r be the inclination of the rain to the vertical, then the relation of the apparent to the true precipitation is expressed by the formula —

$$\frac{\text{Apparent precipitation}}{\text{True precipitation}} = \frac{\cos (r-s)}{\cos r}.$$

If a rain gage is found to be in an inclined position it is important to record the direction of inclination and the direction of prevailing rain-bearing winds. Since the rain does not always come from the same direction it is evident that an inclined gage may give results considerably in error in some showers, and be quite nearly correct in other showers.

There is another matter in connection with the inclination at

which rain falls, which is sometimes of great importance, but which seems to have been generally overlooked. If a rain-bearing wind blows against a mountain slope, then the amount of rain falling on the mountain slope will generally be greater than the amount which would fall on an equal horizontal projected area and greater than the amount caught or measured by a horizontal rain gage.

In a similar manner, the actual precipitation on the leeward side of the slope may be materially less than indicated by a horizontal rain gage. The southeast slope of the Castkill Mountains in New York State affords an excellent illustration of a case where the actual rainfall is apparently greater than the measured amount. The average slope of the mountain side is about 30 degrees. If the rain is blown against this slope at an angle of 15 degrees to the vertical, then the actual precipitation on the prejected area would be 1.16 times the amount measured by a horizontal rain gage.

As already pointed out, the result of wind or exposure error is to make the recorded precipitation usually less than the true amount. The result of error due to location of the rain gage within the influence of a large wind eddy, is to make the recorded amount either greater or less than the true precipitation in the locality.

Taken altogether, there is some preponderance of errors tending to make the measured less than the true amount of precipitation falling as rain, and the tendency is greatly increased for precipitation falling as snow.

If the run-off of a stream for the winter period, November to April inclusive, is compared with the measured precipitation for the same period, it will sometimes be found that the measured run-off is the greater. The ground water and surface storage is usually larger at the end than at the beginning of the winter period, so that the measured run-off will usually represent less than the total available water supply.

If, therefore, the measured run-off is greater than the measured precipitation, it affords evidence that the measured run-off is too great or the measured precipitation too small. There is sometimes a tendency for measured run-off to exceed the true amount during the freezing period. Even where this error is eliminated, cases

still occur which show an apparent run-off greater than the precipitation. It seems probable that in the majority of cases it is due to deficiency in the measured precipitation, which is specially pronounced in the winter and during the fall of snow. Even where measured run-off is somewhat less than the measured precipitation for the winter period, the precipitation may be deficient. The measured run-off should equal the measured precipitation minus

TABLE 9.

Comparative Precipitation at Different Locations in Providence, R. I., in Different Years.

Year.	Mean of First Five City Gages.	Hope Res. El. 162.5.	Fruit Hill Res. El. 275.	Precipitation Plant. El. 25.	Lockanosset Res. El. 182.	Pittaconset El. 25.	U. S. Wea. Bureau Gage. El. 182.	Ladd Observatory.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1909	38.30	38.13	36.18	37.87	39.38	39.92	33.75	40.57
1910	34.96	36.97	33.96	36.58	33.23	34.07	34.21	37.60
1911	40.17	40.62	39.17	39.72	40.18	41.05	36.80	41.52
1912	41.25	42.84	42.65	39.64	40.18	40.95	38.65	44.37
1913	42.93	44.39	43.32	41.08	42.17	43.68	36.94	45.83
1914	37.58	36.68	37.34	35.19	40.35	38.36	29.50	
1915	42.37	44.61	42.19	40.37	42.56	42.11	33.96	
1916	43.90	47.88	40.56	41.37	44.90	44.82	34.44	
Mean	40.18	41.51	39.42	38.98	40.37	40.62	34.78	

the water losses and minus the gain, if any, in ground water and surface storage.

The winter losses due to surface evaporation and inception in the northern states and New England commonly range from 1 to 1½ or 2 in. per month, with the smaller quantities predominating. The difference between the winter precipitation and measured run-off should, therefore, be at least 6 to 9 in. plus the gain in ground water and surface storage, if any.

Comparative Rainfall by Adjacent Rain Gages.

There are but few locations in the United States where rain gages are sufficiently numerous that a comparison can be made between the rainfall of any single gage and the true mean rainfall over the adjacent district.

TABLE 10.

Comparative Precipitation at Adjacent Rain Gages, Pawtucket, R. I.

Year.	Filter Beds. El. 40.	Pumping Station. El. 90.	Masonic Building. El. 140.	Diamond Hill Res. El. 220.	Mean of Four.	Maximum Departure.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1901	49.29	49.27	46.56	57.56	50.67	6.89
1902	49.23	46.70	47.59	47.56	47.47	1.76
1903	48.67	49.81	47.43	46.08	47.99	1.82
1904	51.16	64.58	48.15	42.94	51.71	12.87
1905	41.56	43.66	42.64	38.39	41.56	−3.17
1906	46.72	51.35	50.39	50.28	49.88	−3.16
1907	44.78	48.11	50.29	46.74	47.48	2.80
1908	44.53	41.86	46.98	42.77	43.53	3.45
1909	41.23	38.41	42.13	40.39	40.54	−2.13
1910	36.86	33.26	38.05	30.78	34.74	−3.96
1911	42.26	39.84	42.06	42.98	41.78	−1.94
1912	45.10	43.55	46.49	44.73	44.97	1.54
1913	44.77	42.76	42.33	44.54	43.60	−1.27
1914	38.73	37.74	38.70	38.25	38.36	−0.62
1915	41.46	41.75	43.75	44.52	43.57	−2.11
1916	43.32	43.81	41.01	46.15	43.57	2.58
Mean	44.35	44.78	44.66	44.06	44.46	0.97

Tables 8, 9, and 10 show the relative amount of rain caught by adjacent gages at three locations in New England. At Providence, excluding the Weather Bureau gage, the results for any other single gage are generally within 5 per cent. of the mean of all the other gages, in any single year. This probably represents about as good a degree of agreement and accuracy as is commonly obtainable from different gages located under favorable conditions.

The low catch for the Weather Bureau gage as compared with all the other gages places it under suspicion. The deficiency is probably due to wind action, the gage being exposed on the roof of a building.

TABLE 11.

RAINFALL AT ADJACENT STATIONS AND DEPARTURES FROM THE MEAN IN PERCENTAGES.

Watuppa Ponds, Fall River, Mass., after A. T. Safford.

	Narrows.	W. W. Pump Station.	Read's.	Pettey's.	Hull.	Bleachery.	Average.
			I. — AMOUNTS IN INCHES.				
1899	43.16	40.09	39.56	38.74	47.77	41.47	41.80
1900	43.85	40.87	45.44	40.39	46.77	49.05	44.39
1901	52.77	46.65	53.61	48.07	54.91	57.24	52.21
Mean	46.59	42.54	46.20	42.40	49.82	49.25	46.12
			II. — PERCENTAGE DEPARTURES.*				
1899	+3.2	−3.2	−5.5	−6.3	+14.2	−0.7	+0.28
1900	−1.2	−7.8	+2.3	−9.0	+5.2	+9.7	−0.13
1901	+1.2	−5.6	+2.7	−7.8	+5.2	+9.6	+0.88
Mean	+1.1	−7.7	+0.1	−8.0	+8.2	+8.1	

* Percentage departures of the means given in Part I of the table, from the general average.

A roof exposure does not necessarily imply deficient catch. This is illustrated by the comparison of gages at Pawtucket. The agreement is good, although one of the gages is on a building and there is a total difference of 180 ft. in elevation of the different gages.

The agreement among different gages at Fall River is not so good, but represents about what may commonly be expected under less favorable conditions. The differences here are probably mainly due to location errors, and insufficient shielding, as the gages were standard and the observations carefully made.

TABLE 12.

Precipitation at Various Rain Gages in the City of New Orleans, La.

Year.	No. 1 U. S. W. B. (Roof). Elev. 71 Ft.	No. 2—U. S. W. B. Audoborn "Park." Elev. 4 Ft.	No. 3—Old "A" Dublin. Now at Spruce & Leonidas. S. & W. Bd.—22 Ft.	No. 5—or "C" or Jefferson. S. & W. Bd.—15 Ft.	No. 6—or "D" "Hall" on Roof. S. & W. Bd.—91 Ft.	No. 7—or "E" or "London." 8 Ft.	No. 8—or "F." Now Opelousas St. Algiers.—S. & W. Bd. Elev. 20 Ft.	Mean.	Relation to the Mean. Max.	Min.	Range. Inches.	Range Per Cent. of Mean.	Mean Departure. Inches.	Per Cent. of Mean.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1895	56.44	66.31	62.99	65.59	56.61	58.84	...	61.13	66.31	56.61	9.70	15.9	3.83	6.3
1896	49.68	56.86	51.60	54.37	51.46	61.18	...	54.29	61.18	49.68	11.50	21.2	3.28	6.1
1897	43.47	54.29	54.54	47.74	46.66	53.93	...	50.10	54.54	43.47	11.07	22.1	4.22	8.4
1898	49.00	69.04	60.43	58.77	54.57	55.41	...	57.87	69.04	49.00	20.04	34.6	4.88	8.4
1899	31.07	43.60	39.58	38.14	33.95	43.03	...	38.23	43.60	31.07	17.53	32.8	3.84	10.0
1900	56.33	71.62	67.51	62.73	57.99	63.66	66.38	63.75	71.62	56.33	15.29	24.0	4.08	6.4
1901	57.73	54.43	54.58	50.46	49.48	52.54	55.94	53.59	57.73	49.48	8.25	15.4	2.37	4.4
1902	41.62	39.11	40.18	38.33	37.04	38.83	34.98	38.58	41.62	34.98	6.64	17.2	1.54	4.0
1903	57.18	47.79	57.09	45.13	51.39	51.96	51.44	51.71	57.18	45.13	12.05	23.3	3.17	6.1
1904	43.69	39.22	39.50	37.22	37.31	38.02	43.51	39.78	43.69	37.22	6.47	16.2	2.18	5.5
1905	80.07	71.97	77.87	69.84	71.09	81.02	77.77	75.80	81.02	69.84	11.18	14.7	4.00	5.3
1906	41.60	44.55	39.56	42.20	41.41	44.22	43.90	42.49	44.55	39.56	4.99	11.7	1.48	3.5
1907	66.32	69.36	63.65	61.33	64.26	64.90	63.49	64.76	69.36	61.33	8.03	12.4	1.86	2.9
1908	51.06	57.10	59.59	59.66	59.94	51.70	51.79	55.83	59.94	51.06	8.88	15.9	3.70	6.6
1909	68.18	68.65	66.50	67.55	66.82	64.82	64.47	66.71	68.65	64.47	4.18	6.3	1.24	1.9
1910	51.50	48.79	45.96	49.90	50.11	54.27	47.94	49.78	54.27	45.96	8.31	16.7	1.90	3.9
1911	67.86	60.73	51.03	66.78	69.04	65.62	64.34	63.63	69.04	51.03	18.01	28.3	4.43	6.9
1912	81.50	80.61	63.77	77.97	81.30	76.67	72.19	72.29	81.50	63.77	17.73	23.2	4.75	6.2
1913	63.64	65.86	68.98	64.88	63.57	59.14	57.52	63.37	68.98	57.52	11.46	18.1	2.88	4.5
1914	54.63	54.92	48.15	48.85	53.62	48.57	50.53	51.32	54.92	48.15	6.77	13.1	2.63	5.1
1915	69.28	73.63	54.56	69.51	67.57	59.74	70.29	66.37	73.63	54.56	19.07	28.7	3.84	5.8
1916	59.44	55.37	45.02	52.29	58.17	47.27	54.86	53.20	59.44	45.02	14.42	27.1	4.29	8.1
1917	40.02	33.07	28.58	34.39	37.06	31.12	38.28	34.65	40.02	28.58	11.44	33.0	3.26	9.4
Mean	55.71	57.65	53.96	54.94	54.80	55.06	56.09	55.45	60.51	49.30	11.21	20.3	3.20	5.9

One of the best series of rain-gage comparisons in this country has been made at New Orleans, the results being shown in Table 11.

It is of interest to determine the agreement obtained from different adjacent gages in a region of excessive precipitation. For this purpose Cherrapunji has been selected. Cherrapunji is located in the Khasi Hills, in the province of Assam, India, facing the Bay of Bengal. The mean annual precipitation is 474 in., or nearly 40 ft. — an average of 110 and 120 in. respectively of rainfall occurring in July and August. There was a maximum precipitation for one month of 208 in., in July, 1865. This is equivalent to nearly 7 in. a day, every day in the month. The heavy rainfall mostly occurs during the summer monsoon season, and is due to the warm, moisture-laden monsoon winds blowing off from the Bay of Bengal, and deflected upward by the Khasi Hills. The general location is shown in Fig. 20, and the location and elevation of five rain gages maintained in the village is shown in Fig. 21. Table 12 shows the relative amounts of precipitation caught by four different gages at Cherrapunji in different years.

FIG. 20. LOCATION OF CHERRAPUNJI, INDIA.

The average departure of a single gage from the mean of the four gages is 28.56 in. This appears to be a large amount, but it is only about 7 per cent. of the mean rainfall. Very likely this difference is in part the result of actual difference in rainfall at the different locations, due to their varying elevations. On individual days the percentage variations between the several gages are much larger. It is of interest to note, however, that the percentage variation on individual days varies inversely as the amount of precipitation, the agreement between the gages expressed in

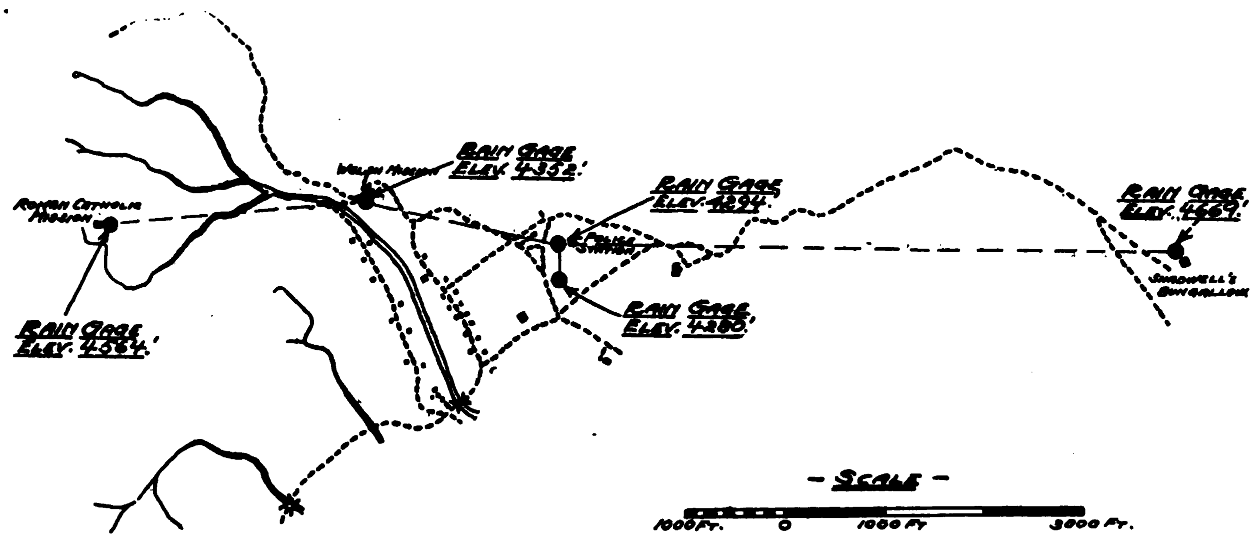


FIG. 21. PART PLAN OF CHERRAPUNJI SHOWING POSITION OF RAIN GAGES AND ELEVATED ROADS.

terms of percentages being much better on days with 10 in. or more of rainfall than on days of very light rainfall.

TABLE 13.

COMPARATIVE YEARLY RAINFALL AT 4 STATIONS IN CHERRAPUNJI, KHASI HILLS, ASSAM, INDIA.

Year.	Stations. Police Station.	Welsh Mission.	Catholic Mission.	Shadwell House.	Mean.	Mean Departure.	Mean Departure in Per Cent. of Mean.	Maximum Dep.	Maximum Dep. in Per Cent. of Mean.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1906	478.54	486.77	445.02	560.09	492.61	33.74	6.85	67.48	13.7
1907	405.92	362.62	310.67	384.67	365.97	29.32	8.00	−55.30	15.1
1908	341.81	284.54	260.21	374.16	315.18	42.80	13.6	58.98	18.7
1909	375.18	334.18	297.77	343.29	337.61	21.63	6.4	−39.84	11.8
1910	561.99	544.88	474.35	519.13	525.09	28.35	5.4	−50.74	9.7
1911	586.57	561.01	488.53	581.13	554.31	32.89	5.9	−65.78	11.9
1912	383.34	390.35	368.57	406.37	387.16	11.20	2.9	19.21	4.9
Mean	447.62	423.48	377.87	452.61	425.40	28.56			

DISCUSSION.

THE PRESIDENT. Are there any questions any one would like to ask Mr. Horton?

MR. DESMOND FITZGERALD.* It seems to me that if there is other business for the afternoon it will be better to get through with that, because the discussion of this paper is likely to take some time, and, perhaps, had better be deferred until a later day. If there is to be a discussion now, however, I should like to take the matter up from the viewpoint of the experiments made many years ago on the Boston water works, and call attention to many points of agreement with the results which Mr. Horton has given

* Past President and Honorary Member, New England Water Works Association: Past President, American Society of Civil Engineers.

us in such an instructive way, and possibly to some points of difference. I think the system of rain gages now included in the Metropolitan supply is an excellent one and gives trustworthy results. I wish also to congratulate Mr. Horton on the industry and zeal with which he has collected so interesting a mass of information, and the trouble he has taken in presenting it to us this afternoon.

THE PRESIDENT. Do I understand you will give us a paper later on the Boston system, Mr. FitzGerald?

MR. FITZGERALD. I will contribute a written discussion of the matter. I am afraid it would take too much time for me to discuss it now.

THE PRESIDENT. We would be very glad to receive your written discussion, or to hear you now, just as you prefer.

MR. FITZGERALD. In regard to this question of altitude of gages above the ground, we built something like eight towers at Chestnut Hill Reservoir some thirty years ago. The gages were so placed that they covered the idea of comparing the results with a pit gage placed level with the surface of the ground. From that point we had gages every five or ten feet up to eighty feet in height. The gages were especially designed to collect the rain so that no loss could take place from evaporation, but they were freely exposed to the wind. Those experiments were kept up for about three years, if I correctly remember, and the lower gages gave the larger results; a result due, I believe, to the action of the wind on the upper gages.

I will say one word now, while I am on my feet, in favor of the system of weighing as against measurement. We found in the course of our investigations that it was easier for an observer to make a mistake in measuring the rain than it was where a proper system of weighing was used. Our gages on the Boston water works were so designed that one one-hundredth of an inch made one ounce in weight. That is to say, the gage was 14.85 inches in diameter; and in a gage of that diameter every .01 of an inch equaled an ounce. The gages were weighed on a common Fairbanks scale and the figures on the scale altered to read hundredths of an inch instead of ounces. That is, 32 oz., for instance, was .32 of an inch and 152 was 1.52 in. of rain. The Fairbanks scales did

not have to be re-made, but simply numbered differently to read inches and hundredths. We got very accurate results from this weighing system.

From an examination covering several years I came to the conclusion that it was extremely difficult to design a gage for both rain and snow, and I gave it up; but we got good results in our measurements of snowfall by the following method: We had a platform on the ground in a clearing in the woods, so that the wind did not affect the results materially. We went to that platform after every snowfall and inverted our gage over it, — there was a piece of tin underneath, — and got all the snow and weighed it. Then we swept off the platform so it was all ready for the next snow. We didn't have snowfalls superimposed one on another.

There is at Chestnut Hill Reservoir a self-recording rain gage that I designed thirty years ago which has been working ever since, and I don't think it has ever had any serious repairs. The results on the sheets are extremely interesting because they are all plotted to good scale and do not require to be interpreted. I hope, Mr. Horton, that you will have an opportunity to examine them while you are in this neighborhood. You will find some very remarkable rainfalls recorded, taken with great accuracy. A cross-section of the apparatus has been published. It is simple and cannot easily get out of order but it is not adapted to the measurement of snow. From the profiles one can study the progress of storms, as they are already plotted to a convenient scale.

The matter of the rainfall always was an interesting one to me. When I first came on to the water works — I think it was in 1873 — I began a serious study of the subject. The gages are made in such a way as to last many years, and they are not easily put out of commission. For instance, you take the average of several gages on the Sudbury River watershed and they must give a close approximation to the mean. As I remember, there was not a great deal of difference between them. The results at that time were quite different from the observations which were taken on one of the high buildings here in Boston. Our records at Chestnut Hill Reservoir were more trustworthy than the

Government records on a high building. There was quite a difference between them, and I think the officials at that time accepted ours as being more accurate. The amount of it is that when you put a rain gage on the top of a high building in the city you get so many whirls of the wind in every direction that it affects the record materially unless some especial precautions are taken, whereas if your gage is properly placed near the ground it is not subject to the same disquieting influences.

THE PRESIDENT. I am very sure that the Association will be glad to put their time against Mr. FitzGerald's, if he will prepare a paper for us on the subject.

MR. R. C. P. COGGESHALL.* We have a wonderful record in New Bedford, what is known as the " Rodman record," that extends considerably over one hundred years. The old gentleman took up the matter as a plaything, years ago, and then his son carried the work along, and when the water works came into existence the work was continued more or less. One of the daughters of the family is Mrs. Colonel Goethals, and it was rather a scientific family.

Our records are kept at the pumping station. We have a set of weighing gages, — and during the past year have got a record there of only a trifle over 36 in., which is the smallest since 1914. It is no wonder that our water supplies are rather short at the present time. The city engineer keeps a record on top of the municipal building, and for some reason he doesn't get anywhere near as much rainfall as we do.

MR. FITZGERALD. The rainfall in the Philippines has been referred to. Benguet is not exactly on the side of a mountain. It is what is called the summer capital of the Philippines and is about 5 500 ft. above the sea. It is on an elevated plateau in a mountainous district.

There is great diversity within short distances in this matter of rainfall. On the Pacific coast, in Oregon or in Washington, we have a rainfall of perhaps 90 in. from the warm Japanese current. That moisture is carried by the westerly winds up the

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* Past President, New England Water Works Association; Superintendent, Water Works, New Bedford, Mass.

cold sides of the mountains, and precipitated in the form of heavy rain. It is that large rainfall that produces the big trees, and not the trees which bring the rain. When the clouds get on the other side of the mountains they have no more rain to precipitate, and we have a much smaller rainfall on the easterly side. I remember the enormous records of rainfall in the Calcutta region referred to by Mr. Horton, where they have a record of over two feet of rainfall a day for three days. Of course it is utterly useless to try to keep bridges over the rivers in view of such rainfalls as that. You must simply have an open outlet to the sea for it.

MR. CHARLES W. SHERMAN.* With reference to the difference between the rainfall measurements on high buildings and those on the ground, I have recently had opportunity to make an extended comparison between the record of the recording gage at Chestnut Hill Reservoir and that at the station of the Weather Bureau in Boston. The latter does not cover so many years by fifteen as the former does, but the comparison was made covering just the same period at Chestnut Hill as the entire period of the Boston record. The same storms, or storms coming on the same day, were found to differ very widely. It might very well be so, the gages being five miles apart, more or less. But it is very interesting to note that throughout the period covered by the records, which I think is something like twenty-six years, the average results are substantially identical. I do not mean that closely comparable results were necessarily obtained for particular storms, but that the relations between time and intensity of precipitation, and the frequency of storms of various iutensities, agreed very closely. I am inclined to think that that means that the Weather Bureau, beginning about the time of the installation of the recording gage in Boston, has taken very much more pains in the setting and adjustment of its gages on high buildings in the larger cities than it did in the earlier years. I think that the criticism of the rain-gage records on high buildings in early years is amply justified, — I think they are entirely untrustworthy, — and I think many of them at the present time are, unless they are very carefully safeguarded. I have the impression, however, that the

* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

Weather Bureau in its important stations has given much more attention in the last twenty-five years to protecting its gages by screening or otherwise, and that such gages generally now give results much more trustworthy than those of the earlier years.

MR. X. H. GOODNOUGH.* I hope, Mr. President, that Mr. FitzGerald will print his experiments in the Society's publication. I think they are among the most interesting, in fact, decidedly the most interesting and most valuable ever carried out in this state, and it seems to me it would be a very great aid to all the members of the Association if he would be willing to prepare them for publication in the Society's JOURNAL. They cover the whole range of the subject, and bear especially on this question of elevation,

There is one other point I should like to emphasize again, which was brought out in the paper, and that is the extremely small number of rainfall stations in New England. I think half of the whole number are in Massachusetts, and more than half of those are in eastern Massachusetts. The number is increasing, but even now there are very wide spaces in which no rainfall station exists.

The study of rainfall was very well begun by the New England Meteorological Society in 1884. They maintained for a time a journal, and did the first work which was important or successful, it seems to me, on this subject. Of course the work was begun in many ways years before that. I think that the Government began to make observations of the rainfall in the very early part of the nineteenth century, and there are a lot of those old records now in existence. Then I think there was a law in the state of New York under which observations were made at all the academies, for many years. Later on, the enthusiasm in the measurements of the rainfall dropped off. Then the Government came in again, but does not maintain stations enough to furnish satisfactory records of the rainfall in many of the watersheds. It seems to me that the Government is not especially to blame, but that it is we who are to blame for not urging them and for not insisting on a greater number of observations, and then helping in every

* Director and Chief Engineer, Mass. State Department of Health.

way that we can. The question is a very important one, especially now when questions of waterways development and power development are coming up, and it is not too late to begin even now to try to secure a greater number of observations.

SOME PRACTICAL USES OF RAINFALL RECORDS.

BY L. M. HASTINGS, CITY ENGINEER, CAMBRIDGE, MASS.

[*Read February 12, 1919.*]

At the December meeting of the New England Water Works Association, a letter was read from Robert E. Horton suggesting that an effort be made to get officials in charge of water works to establish rain gages at the watersheds upon which their water supply depends.

While there are a fairly good number of rain gages established in various parts of New England now, the number might be greatly increased with good results, especially if they were established in locations not already closely covered by existing observers.

The accompanying map, reproduced from that given in a paper by Mr. X. H. Goodnough, on "Rainfall in New England," JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, Vol. XIX, No. 3, shows the location of most of the rain gages as in service in 1914 — about 194 in all. It will be observed that the southeasterly corner of New England is well supplied with rain gages, but that there are in the remaining sections of New England large areas where the gages are very widely separated. Many of these sections are well elevated, with many streams, and opportunities for reservoirs, dams, etc., for the development of power or water supplies. (See Fig. 1.)

If, as is recommended so strongly at the present time, a careful study of the streams and water courses of the country is to be made with a view to their more complete development as a source of power in order to conserve the consumption of coal as a power producer, the establishment of numerous rain gages in various parts of the country will be found exceedingly useful in the study of that important question, as well as the one in which the members of this Association are more directly interested, viz., the development and conservation of our streams as sources of domestic water supplies.

It is proposed in this paper to give a few simple illustrations of ways in which rainfall records may be put to practicable use in

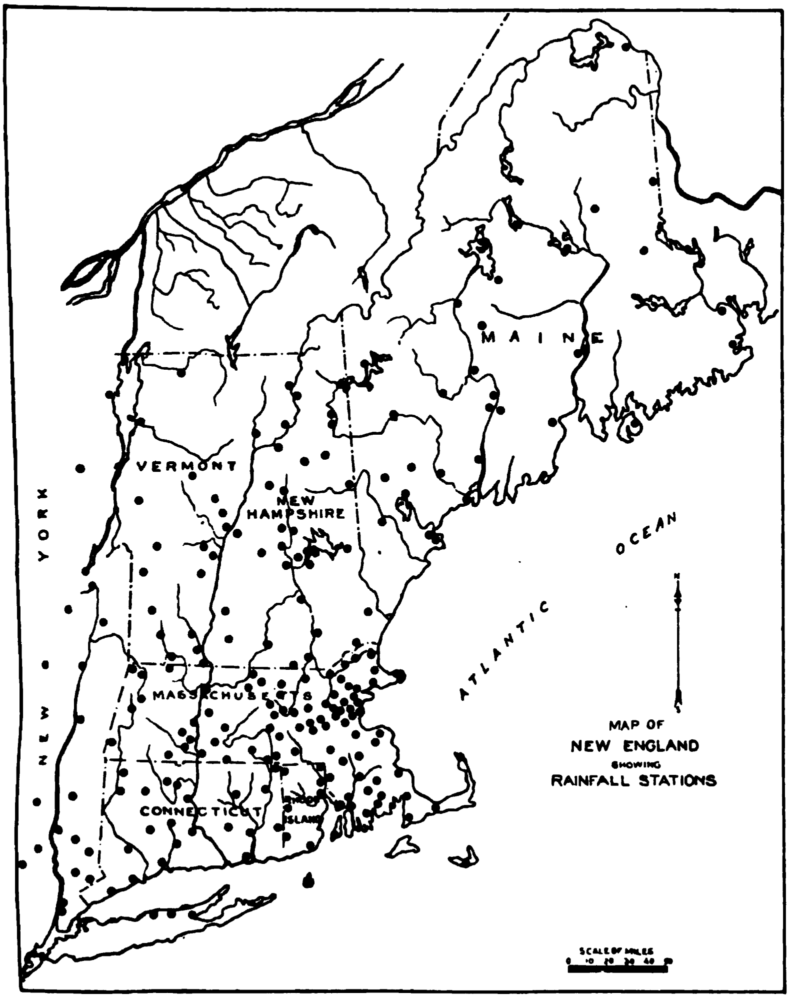
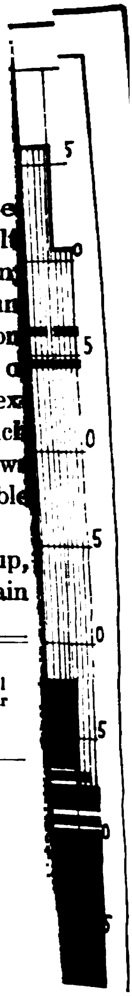


Fig. 1.

the study of questions relating to water power and water supply, and so encourage the establishment of additional gages.



One advantage to be gained by having gaging stations located at relatively short distances apart would be to check the results so obtained by those obtained at other stations and correct any variation which may appear in the gaging due to special or unusual topographical conditions in the watershed, such as elevation, nearness to large hills, mountains, or water surfaces, directions of prevailing winds, etc. As the amount of rain which may be expected to fall in a given district is often the only basis upon which its value as a power or water producer can be found, it follows that it is desirable to have the very best data that it is possible to obtain on that vital point.

It may be thought that with so many rain gages already set up, especially in eastern New England, it would be easy to obtain

Location.	Average Yearly Rainfall, 1874–1913, 40 Years.	Rainfall for Year 1880.	Rainfall for Year 1883.
Manchester, N. H.	38.27	27.30	31.47
Concord, N. H.	38.63	30.48	31.35
Lowell	42.01	35.28	39.84
Waltham	43.36	31.73	29.32
Cambridge, Harvard College	43.49	35.22	32.65
Framingham, Sudbury River	44.26	37.87	31.95
New Bedford	46.65	40.06	43.51
Providence, R. I.	47.20	41.29	39.54

accurate and reliable data for almost any location in that section; but any one not familar with the subject will be surprised and puzzled at the wide variation in the results obtained at locations not far apart, which often renders any close estimates impossible. As illustrating this fact, the above table has been prepared showing the average rainfall at various stations in eastern New England for a forty-year period ending 1913, and also the rainfall for the exceptionally dry years of 1880 and 1883, which for some purposes it might be desired to use. Manchester, N. H., and Providence, R. I., are only about eighty miles apart in a straight line.

PLATE I.
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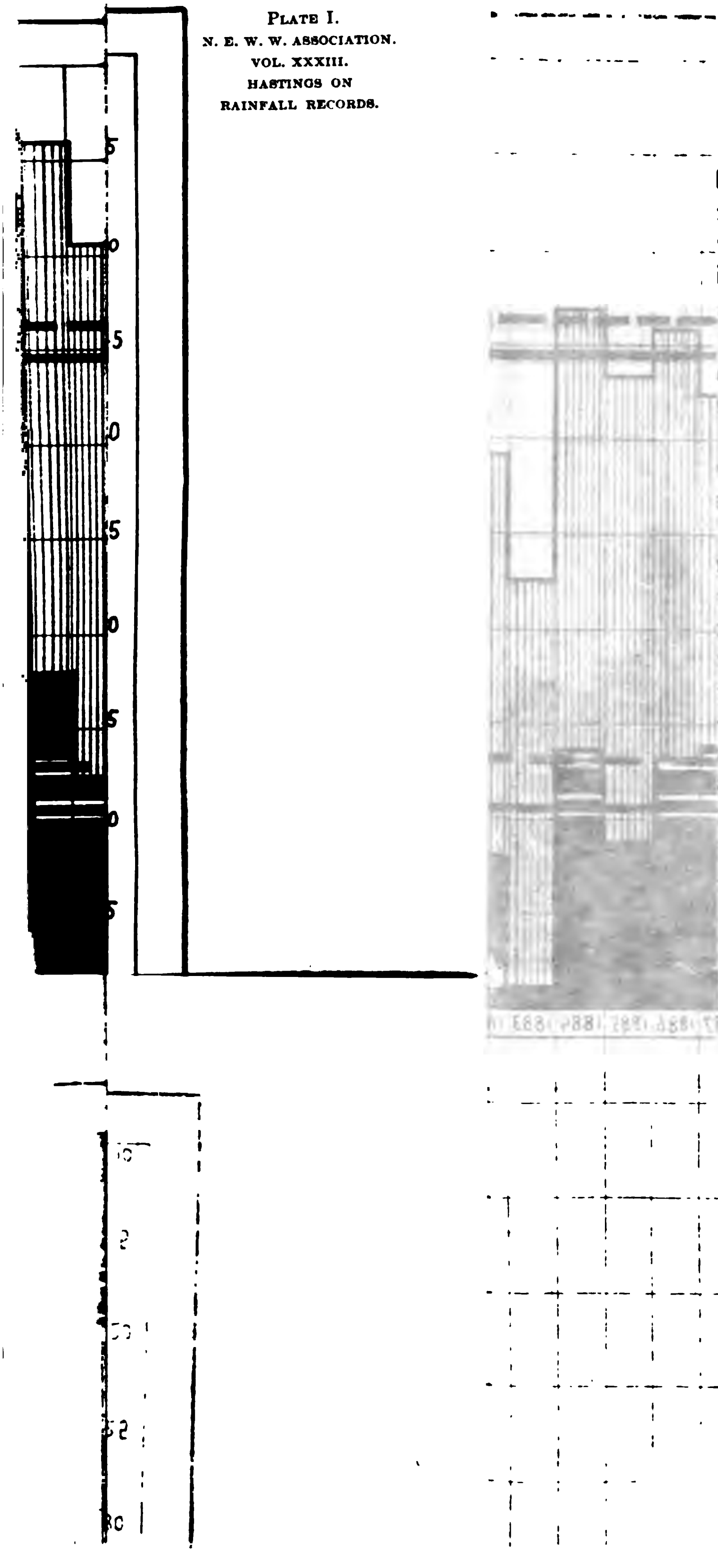

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From the above it will be seen that even for a long-term period the average amount of rainfall at the points named varies greatly, the extreme variation being 8.93 in. or about twenty-three per cent. while for the dry year of 1880 the extreme variation is 13.99 in., or over fifty per cent. From this it will be seen that any one attempting to design a water-power or a water-supply system for a watershed at all remote from a long-established rain gage must unavoidably make his estimates upon data which have a large element of uncertainty in the makeup.

It has been stated by some writers that a rainfall record of from thirty-five to forty years makes that record fairly reliable as a basis of estimates for the expected average yield of a watershed. While this may be true for an ordinary forty-year period, an examination of the rainfall records of the last forty years of the Sudbury River watershed, and others which have commonly been used in this vicinity, shows that a marked change in the amount of rainfall has occurred during the last fifteen years of that period, and that, while the average for the forty-four years since the Sudbury River records were begun is 44.66 in., the average for the period 1904 to 1918 (fifteen years) is only 40.97 in. (See Plate I.)

The Stony Brook rainfall record of the Cambridge Water Works in Waltham, Mass., shows a similar change. While the average rainfall for the entire period of twenty-nine years the gage has been established — 1890 to 1918 — is 41.53 in., the average for the period 1904 to 1918 (fifteen years) is 38.75 in.

These last are remarkably low average rates for so long a period, and there seems to be but one period of that length of time with so low a rainfall record in this vicinity. This is the Cambridge record of Prof. John A. Winthrop, from 1760 to 1775, where the average rainfall is shown as 37.38 in., as given by Mr. Goodnough in his paper already referred to.

Still further, the record of the yield or run-off for both these areas shows a corresponding persistent decrease. While the average run-off from the Sudbury River area for the forty-four years is 20.54 in., the average run-off for the last fifteen years is 15.85 in. On the Stony Brook area, the average run-off for the twenty-nine years is 17.81 in., and the average run-off for the last fifteen years is only 15.70 in.

If these records are analyzed by percentages, the interesting fact is shown that in the dry periods the *proportion* or *percentage* of run-off to rainfall is less than that in the wet periods. Thus, for the wet period in the Sudbury River area, 1875 to 1903, the run-off was 49.3 per cent. of the rainfall, while for the dry period 1904 to 1918 it was only 38.7 per cent.; while for the exceptionally dry year of 1883 it was 34.1 per cent., and for the year 1911 it was 28.1 per cent. Similarly, on the Stony Brook area, for the wet period 1890 to 1903 the run-off was 42.9 per cent. of the rainfall, and for the dry period 1904 to 1918 it was 40.5 per cent., and for the year 1910 it was only 27.1 per cent. of the rainfall. In other words, a diminished rainfall gives not only a diminished run-off, but a *diminished proportion* of run-off. From these facts, it is evident that it may not be safe to draw conclusions even from a forty-year record, without a careful study of the records of other places and other periods, that proper allowance may be made for abnormal results which may have been obtained.

There is another rather curious fact shown in the records for the year 1909 which may be noted. While the rainfall for this year is about 6 in. more than for either the years 1908 or 1910, the *run-off* for 1909 is about 1.50 in. *less* than for the year 1908. The Stony Brook record shows the same peculiar result, — a lessened run-off in a year of increased rainfall. The explanation of this anomaly may be that the underground storage had become so depleted by the continued drought of a number of years that the increased rainfall for the one year failed to restore the deficiency in this storage and so caused a lessened run-off for that year.

A very important and interesting question may be raised just here. Will the diminished rainfall as noted during the last fifteen years be permanent or will the rate " come back " to its old level? While no definite or authoritative answer can be given to this query, two things should be remembered in this connection. No permanent marked changes ever take place in the processes of nature without adequate cause. No such adequate cause is apparent by which the rainfall of this section could be permanently diminished, and again, in the past marked changes have occurred in meteorological conditions, — cold winters, hot summers, wet and dry seasons, — some continuing for considerable lengths of

time, but inevitably the balance has been restored and the general mean of conditions reëstablished. Even if the period of low rainfall given in Professor Winthrop's somewhat fragmentary records be taken as reliable as showing the entire rainfall for that

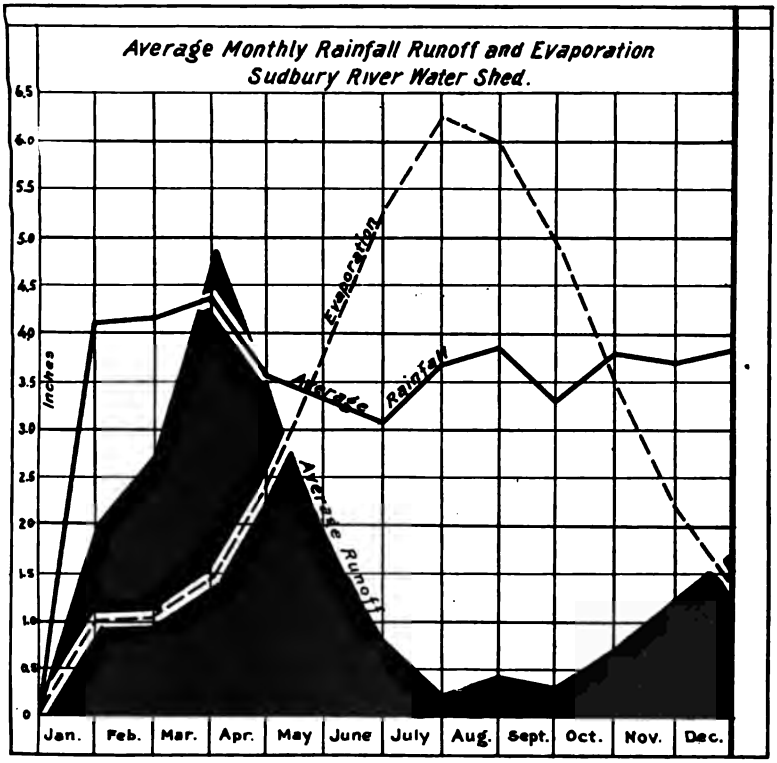

FIG. 2.

period, the records of other observers for following years show the amount of rainfall to be well up to or above the average.

A very practical and convenient way of using the daily rainfall records is by plotting them in the form of a mass diagram. Probably one of the most common inquiries a superintendent of water works has to answer is one relating to the condition of the reservoir as regards the supply in storage. Much misconception frequently

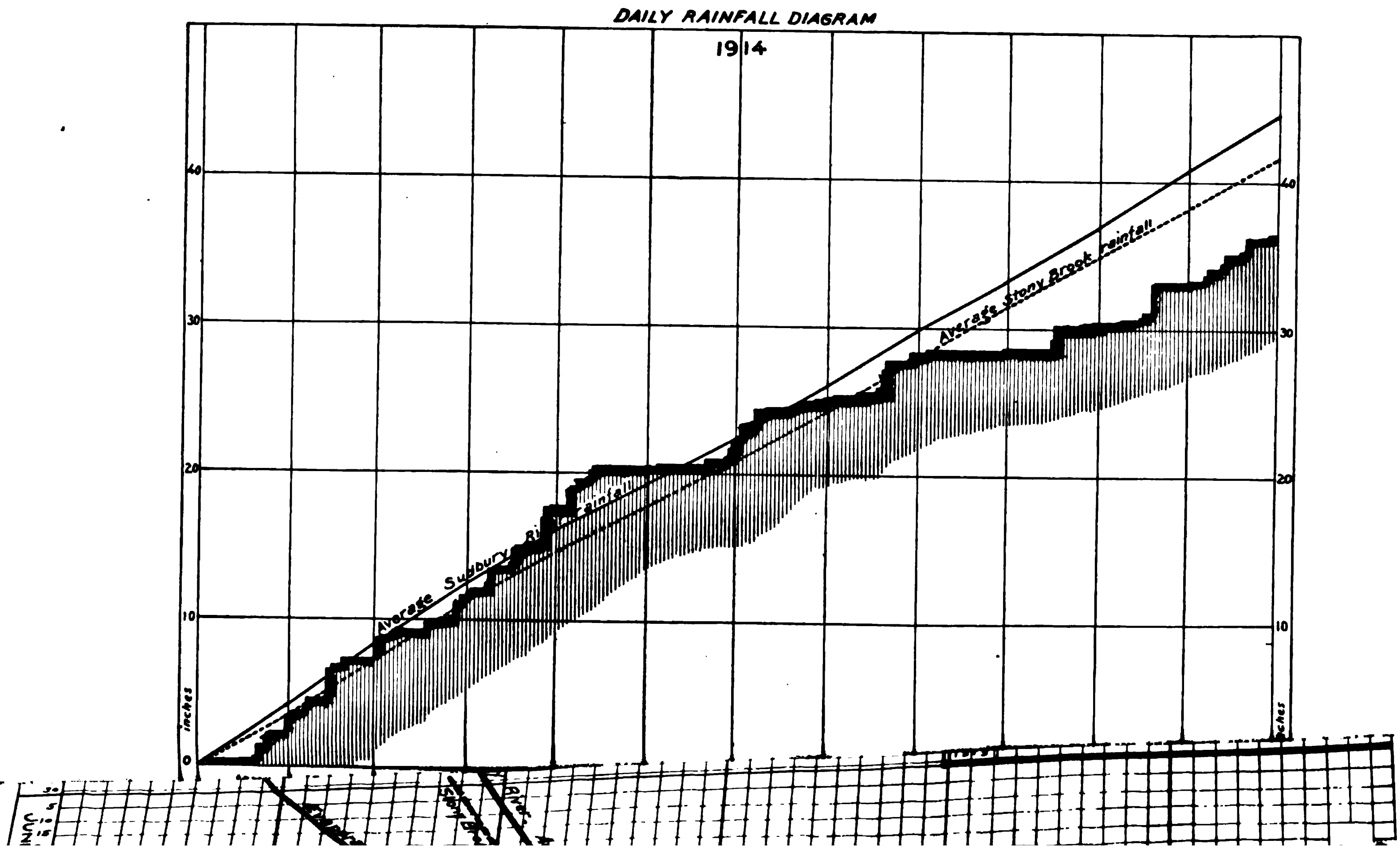
DAILY RAINFALL DIAGRAM
1914
inches
0
10
20
30
40
Average Sudbury River rainfall
Average Stony Brook rainfall
inches
JUNE

PLATE II.
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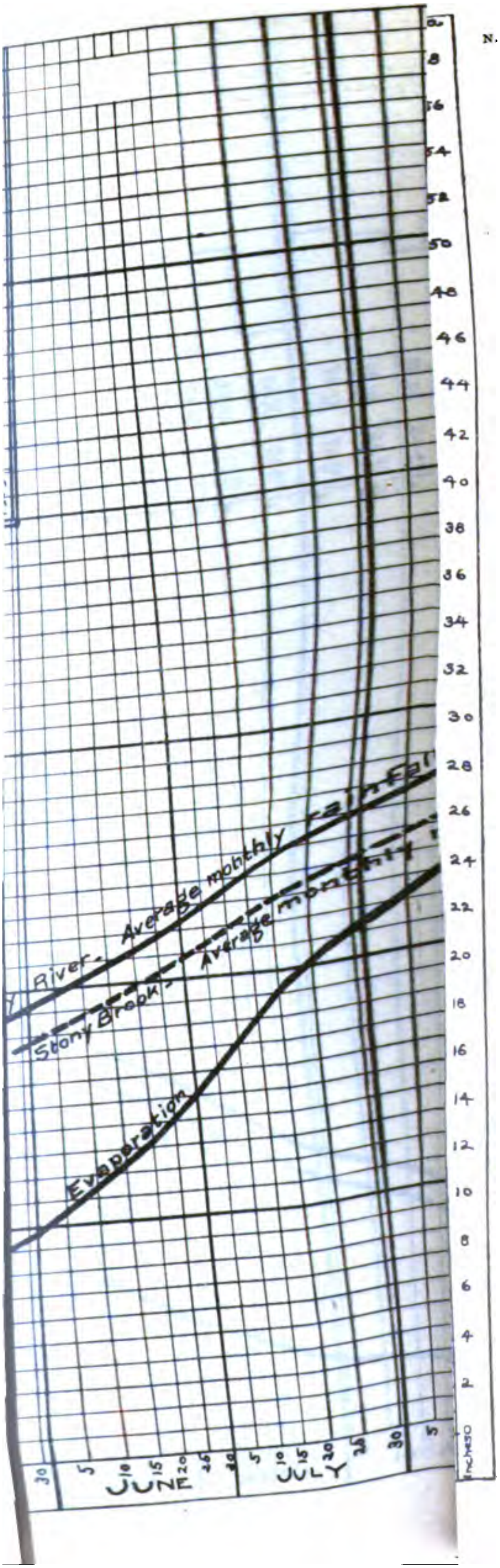

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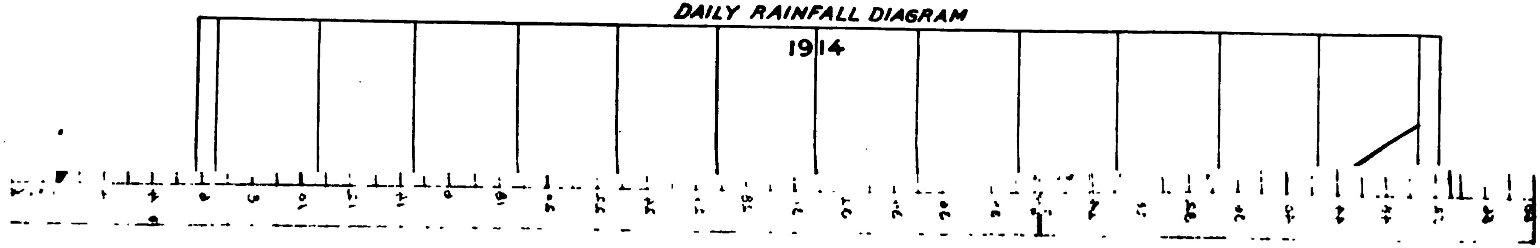
DAILY RAINFALL DIAGRAM

1914



exists in the " average citizen's " mind as to the amount of rain which has fallen to a given date, and consequently as to the amount of water which has been received into the storage basins.

If the returns are plotted on the prepared skeleton or frame of the diagram at weekly or monthly intervals, a glance will show just how the matter stands with regard to the total amount of rainfall to date, and also whether that amount is more or less than the average amount of rainfall up to that time. (See Plate II.)

It is rather a curious fact that, taking a long term of years, the average rainfall for each month differs but little, the rainfall of the so-called " dry months " being on the average but little less than that of the wet months. The greatly increased evaporation during the hot months, together with the demands of growing vegetation, etc., makes the rainfall seem much less than it really is and results in a greatly decreased run-off during those months. As the evaporation from ponds, brooks, reservoirs, etc., amounts to over 39 in. during an average year, it will be seen that the presence of large water surfaces in a watershed may have an important bearing on the amount of run-off to be expected from it. The accompanying diagram shows very clearly the relation between the average rainfall, evaporation, and run-off, as they occur in the Sudbury River watershed. (See Fig. 2.)

The distribution of the rainfall during the year has an important bearing on the amount of the yield or run-off. If the rainfall is largely during the season when the ground is frozen, a much larger run-off may be expected than if it occurred during the hot months, when the ground is dry and the evaporation rapid. This distribution and also the accumulated amount of rainfall to any date during the year can very graphically be shown by plotting each rainfall record on a print of the skeleton diagram shown on Plate II. The rainfall records of 1914 and 1915 are thus shown on Figs. 3 and 4.

From the above it will be seen that rainfall records can be made to serve a variety of practicable purposes, and that long time records obtained on or near the ground are most reliable and satisfactory.

The cost of an ordinary rain gage (not automatic or self-recording) is small, and its care and maintenance require only the atten-

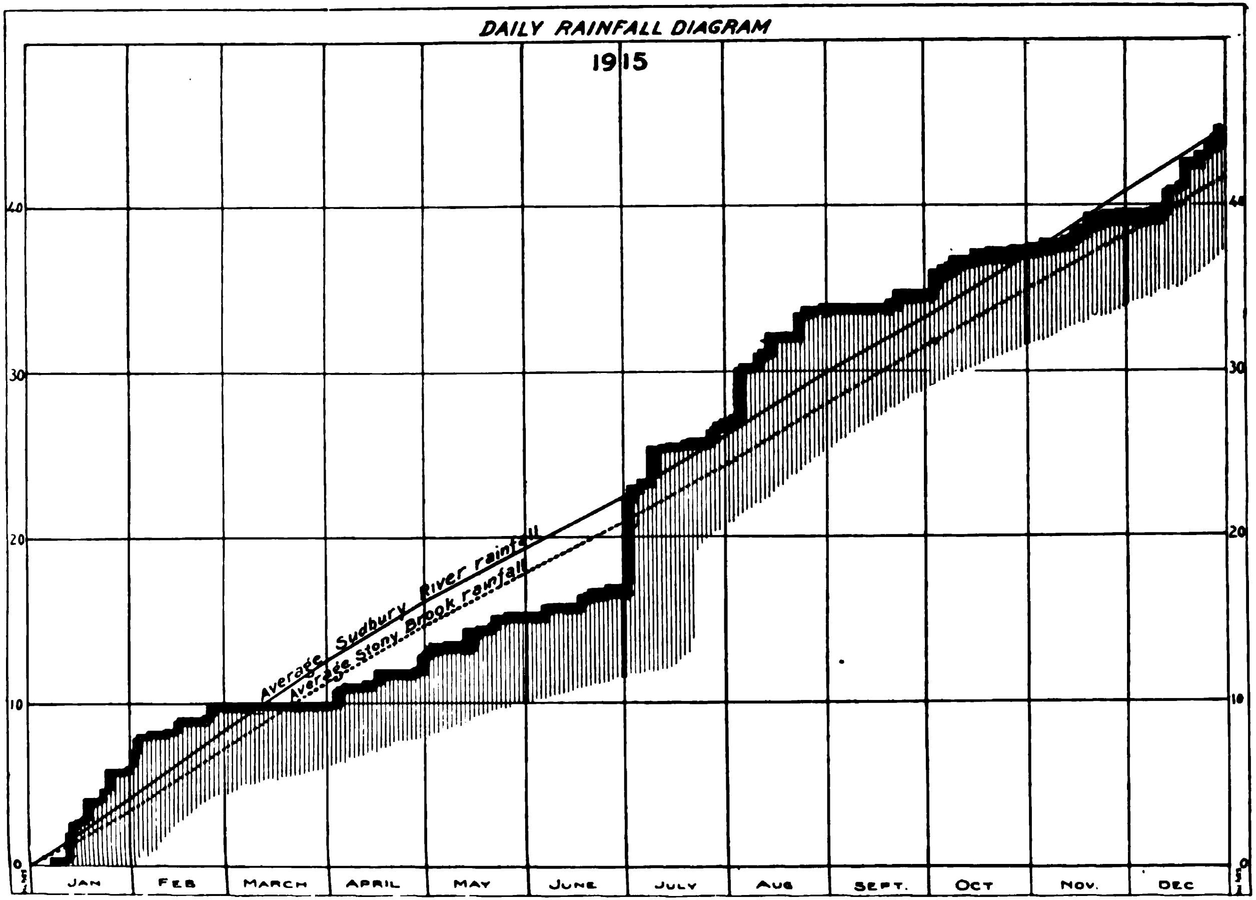

DAILY RAINFALL DIAGRAM
1915
Average Sudbury River rainfall
Average Stony Brook rainfall
0
10
20
30
40
JAN
FEB
MARCH
APRIL
MAY
JUNE
JULY
AUG
SEPT.
OCT
NOV.
DEC

Fig. 4.

tion which can be given to it by some intelligent employee on the ground, or by some resident for a nominal sum. The United States Weather Bureau standard rain and snow gage is shown in Fig. 5.

If it is desired to obtain automatic records of the rainfall, a more complicated and expensive type of gage can be installed, and data obtained very useful in the study of many questions not

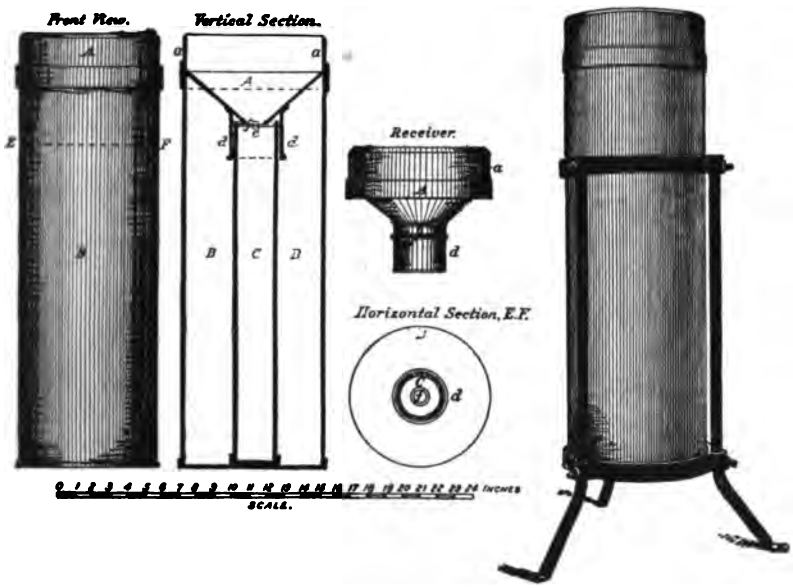


FIG. 5. RAIN AND SNOW GAGES.

covered by the mere *quantity* of rainfall, especially such as relate to the time at which the rainfall occurred and its intensity or rate per hour at any given time. These data are very interesting, and sometimes are exceedingly valuable as factors relating to the required strength and height of dams, length of spillways, size of culverts, damages caused by floods, overflows, washouts, raising or lowering of the water in storage reservoirs, and a great variety of other questions of a similar nature.

If a watershed is large, and the works established upon it are important and involve a large investment of capital, the establishment of an automatic rain gage is strongly recommended.

PROCEEDINGS.

December Meeting.

Hotel Brunswick, Boston, Mass.,
Wednesday, December 11, 1918.
2 P.M.

President Davis presiding.
The following members and guests were present:

Honorary Members.

E. C. Brooks.	R. C. P. Coggeshall.	R. J. Thomas. — 3.

Members.

D. L. Agnew.	Patrick Gear.	Leonard Metcalf.
S. A. Agnew.	F. J. Gifford.	H. S. Noyes.
L. M. Bancroft.	H. J. Goodale.	F. L. Northrop.
F. A. Barbour.	L. M. Hastings.	T. A. Peirce.
J. F. Barrett.	T. G. Hazard, Jr.	A. E. Pickup.
G. W. Batchelder.	D. A. Heffernan.	William Plattner.
C. S. Beaudry.	J. L. Howard.	H. W. Sanderson.
C. R. Bettes.	A. C. Howes.	C. M. Saville.
A. E. Blackmer.	J. A. Hoy.	A. L. Sawyer.
Bertram Brewer.	J. W. Kay.	C. W. Sherman.
F. L. Cole.	E. W. Kent.	G. H. Snell.
J. E. Conley.	Willard Kent.	W. F. Sullivan.
John Cullen.	S. E. Killam.	H. A. Symonds.
C. E. Davis.	G. A. King.	L. D. Thorpe.
A. O. Doane.	P. J. Lucey.	E. J. Titcomb.
L. R. Dunn.	Thomas McKenzie.	W. H. Vaughn.
E. D. Eldredge.	Hugh McLean	J. H. Walsh.
Frank Emerson.	H. V. Macksey.	R. S. Weston.
S. F. Ferguson.	J. H. Mendell.	I. S. Wood.
F. L. Fuller.	F. E. Merrill.	M. B. Wright — 60.

Associates.

Bond, H. L., Co., by F. M. Bates.
Builders Iron Foundry, by A. B. Coulters.
Chapman Valve Mfg. Co., by V. N. Bengle and M. E. Lynch.
Donaldson Iron Co., by C. F. Glavin.

Eddy Valve Co., by H. R. Prescott.
Engineering News-Record, by I. S. Holbrook.
Hersey Mfg. Co., by J. H. Smith.
Lead Lined Iron Pipe Co., by T. E. Dwyer.
Mueller, H., Mfg. Co., by C. J. G. Haas.
National Meter Co., by H. L. Weston.
Neptune Meter Co., by H. H. Kinsey.
Pittsburgh Meter Co., by J. W. Turner.
Rensselaer Valve Co., by I. A. Rowe and C. L. Brown.
Smith, A. P., Mfg. Co., by F. L. Northrop.
Thomson Meter Co., by E. M. Shedd.
Union Water Meter Co., H. W. Jacobs and D. K. Otis.
Water Works Equipment Co., by W. H. Van Winkle. — 20.

GUESTS.

MASSACHUSETTS.

Boston, G. C. Northrop.
Cambridge, Timothy W. Good.
Fall River, John W. Moran.
Groton, Arthur Wood.
Kingston, P. H. Delano.
Stoughton, E. E. Randell. — 6.

Singing: " America."

The Secretary read the following list of applicants for membership, approved by the Executive Committee:

Timothy W. Good, Cambridge, Mass., general superintendent Cambridge Water Department; Launcelot Paul Marshall, Rangoon, Burma, India, chief engineer, Rangoon Municipality; V. T. Givotovsky, Allston, Mass., student at M. I. T.; W. A. Keene, Turtle Creek, Pa., manager of Turtle Creek office of Pennsylvania Water Company; John W. Moran, Fall River, Mass., superintendent Fall River Water Department. — 5.

On motion of Mr. Edward N. Cogswell, the Secretary was instructed to cast the ballot of the Association in favor of the applicants named, and he having done so they were declared to be elected members of the Association.

PRESIDENT DAVIS. The Secretary has a letter, received from Mr. Robert E. Horton, which I would like to ask him to read, as it contains some very interesting suggestions on which I think the Association may care to act.

(Letter from Mr. Horton is read by the Secretary.)

NOVEMBER 18, 1918.

MR. WILLARD KENT, C.E.,
NARRAGANSETT PIER, R. I.

Dear Sir, — I would be pleased if you would call to the attention of the New England Water Works Association at its next regular meeting the advisability of collecting and publishing annually through the medium of a standing or special committee, results of stream flow and rainfall observations taken in connection with water-works systems throughout New England. The Society had laid an excellent foundation in the valuable papers on these subjects by Goodnough, relative to rainfall, and of the committee on yield of drainage areas relative to run-off. There are many rain gages maintained in conjunction with water-works systems in New England the results of which do not appear in the reports of the U. S. Weather Bureau. Probably most of these gages are subject to more frequent inspection and more personal care than the Weather Bureau has generally been able to give to rain gages maintained by its voluntary observers.

There are also many records of the yield of streams, especially small streams used for water-supply purposes, the results of which do not appear in the reports of the Geological Survey on stream gaging matters.

Rainfall data alone are valuable, and run-off data alone are valuable; but rainfall and run-off data where both are given for a particular drainage basin are much more valuable than either class of data alone. The records now being kept in conjunction with water-works systems in New England furnish many instances where these extremely valuable data may be obtained. Most of these records are kept under the direction of members of the New England Water Works Association. It would not involve a large amount of labor to collect these results year by year and publish them in one of the issues of the JOURNAL of the Association each year.

I respectfully request that this matter be called to the attention of the Association, and, if possible, an arrangement made to carry out this or some similar plan.

Yours very truly,

ROBERT E. HORTON.

PRESIDENT DAVIS. It seemed to the Executive Committee that that was a very fruitful suggestion and might result in bringing together a great deal of useful information. Have any of the members any thought in regard to the matter? Have you any comments or criticisms? The Executive Committee was inclined to appoint a committee, in a tentative way at least, to start this proposition and see if anything could be done, and if there is no objection I presume that that committee will be appointed and be asked to act.

Mr. Charles W. Sherman. To remove any doubt, if there be any doubt, I move that the matter be referred to the Executive Committee with power.

(The motion was seconded.)

Mr. Leonard Metcalf. Mr. President, might it not be well to couple with that also the statement that it is the sense of this meeting that it would be distinctly to the advantage of the Association to appoint such a committee? It seems to me that the suggestion by Mr. Horton is a very happy one, and the committee that may be appointed by the Executive Committee, and the Executive Committee itself, can determine after the material has been assembled how far it is well to publish it; in other words, whether it is worth publishing or not. But it certainly must be true, as Mr. Horton says, that there are many records available that have not been given publicity, that would broaden the field of useful information in such matters, and it is well that we should have it in hand.

President Davis. When it was discussed this morning it was thought that, to begin with at least, there could be published an index of what data there were, and that the data could be compiled to be furnished to every one when wanted. Possibly, later on, it might be published more completely. At least we could start it with an index of the data that were available, which could be had upon application. I assume that Mr. Sherman accepts Mr. Metcalf's suggestion. Are there any further comments?

Mr. L. M. Hastings. I would like to say a word in regard to that. I want to second the motion most heartily, because I know from experience that there is a good deal of information in regard to rainfall and run-off — particularly rainfall, at any rate — amongst the water works of New England. And I know from experience that such data are very desirable to have. We have some data obtained here in New England, some in New York, and some in the more western part of the country. It is very essential, very useful, for every engineer who has to do with water works, either in the capacity of water supply or mill power, or in any other way where water is used either for power or domestic purposes, that the data to be used shall be obtained from localities near at hand. You can go to the western part of the country and of

course get rainfall data which would be of absolutely no value in this part of the country. If we start this movement to collate data in regard to rainfall and run-off, perhaps some of the super-intendents in New England who have not established rain gages may be induced to set them up, if they felt that the data which they got would be not only useful to them but to others, and that they would have the use of the neighboring data. I might say that the establishment of a rain gage on a watershed is a comparatively inexpensive matter, and the maintenance of a suitable, accurate rain gage which gives you just simply the amount of rainfall, is very easily done, and it would be a simple matter for most superintendents to have rain gages set up on their water-sheds, one or more in number, and the data in that way obtained. If this Association, with its large membership, would do that, I am sure that a mass of accurate and reliable data could be very readily obtained which would be extremely useful. It is a well-known fact that the longer a rain gage, for data of that kind, is kept up, the longer the period over which it extends, the more useful and reliable that data is. So that if we could set up twenty-five gages in different parts of New England and keep them for forty years, we would have a mass of information and data there that would be very useful indeed. I heartily support the motion and I hope it will prevail, and not only that we will get the records of what rain gages there are at present maintained but that new ones will be set up and maintained as well.

President Davis. There is one thing I might have said. As I recall it, Mr. Horton's letter would limit it to the New England states. I don't think that is at all necessary. I think that the data might be sent in from any of our members, wherever located, provided they obtained a record that was useful. What would you think about that, Mr. Hastings? It would not necessarily be limited to New England alone, would it?

Mr. Hastings. No, sir; I think not. I think it would be interesting, although the farther away you get from your *locus* the less value it would have.

President Davis. But it would make our Association a headquarters for a great deal of information that would not be obtainable anywhere else. The more widespread geographically,

the more use the Association would be to the general public. I do not believe the New England Association ought to take any action which tends to identify its name with its membership; I believe it is country-wide.

A MEMBER. Along the line of what you have just suggested, I hope that you and the Association and the committee won't start out with the idea of publishing rainfall records all over the United States. When you consider the number of pamphlets issued yearly by the Geological Survey and the various branches of the Government, you can imagine where the Association would be if we published the rainfall records all over the United States.

PRESIDENT DAVIS. Well, I rather assumed that Mr. Horton's idea would be to bring together in New England that which was not published elsewhere, — the gages and records that are overlooked in the other publications. I agree with you that we can't have everything.

A MEMBER. I hope that the members of your committee will have an independent income and have nothing else to do.

PRESIDENT DAVIS. I do not believe the work of the committee need be too arduous. It perhaps may make one or two suggestions as to the form in which the data might be sent in. The work of the committee will grow as the reports come in. I do not believe the committee will be swamped with work.

(The question was put and carried.)

PAINTING STANDPIPES.

PRESIDENT DAVIS. The first paper this afternoon is "Painting Standpipes," by Mr. Charles W. Sherman. I understand Mr. Sherman's paper is not complete, and that he is not prepared to do more than make a few remarks to-day on the general subject, and there will be no discussion of the paper until a further date.

MR. CHARLES W. SHERMAN. I had not contemplated making even a general presentation to-day. Mr. Kent made out the program, and as I had promised this paper for the November meeting, when the Government work prevented me from preparing it, he doubtless assumed that it would be ready in December. Under

ordinary conditions that would probably be a reasonable assumption, but it did not work out so at this time.

Most of my data were accumulated two years ago, and I have not had an opportunity to look at them for nearly that length of time; consequently, I am not in a position to say much about the subject now. However, to satisfy the curiosity of some of the members who responded to my inquiry at that time, when a questionnaire was sent asking for information about their experiences with painting standpipes, and in order that they may know that it is not lost for all time, I will say that I made some preliminary steps towards tabulating the information, as far as it loaned itself to tabulation; but the net result is that, taking it by and large, the water-works men do not know very much about painting standpipes.

There are a few cases where they have very good records, but in a very surprisingly large number of cases the response came back something like this: "I have only been superintendent a short time, and my predecessor left no records, and I do not know what he put on the standpipe or when it was painted." When we get back to it, it means that all the money which water-works men have spent in painting standpipes has been in a more or less haphazard way, and the information we have been able to get has been almost nothing.

The data which I have, and which I hope to be able to present at a later meeting, are all that I have been able to compile from these returns, showing the kind of paint, as far as we can tell from the returns, — whether graphite or asphalt, or something else — and you know for yourselves what "graphite" or "asphalt" may mean,— it may mean anything. And as to the information relative to the treatment of the surface in preparation for painting, it is of a most meager character as a rule. And most of the other information runs along the same line. You can perhaps get some general information from the replies as to how often, under circumstances that have existed, standpipes have had to be painted. You will find one or two cases, perhaps three or four, where standpipes are twenty years or more old, and they say they have never seen the inside of them; they have never been opened since erected, and they "assume" they are in good condition. At

any rate, they have gotten by. But the superintendent who lets the standpipe go that way is taking a bigger chance than I would care to do, I think.

PRESIDENT DAVIS. We certainly do not want to discourage anybody who has come on here to take part in the discussion.

MR. H. A. MILLER. Mr. President, I am very much disappointed that we are not able to hear something about the paint, because, whenever I am up against painting anything, I always get sort of a nervous chill, as I do not know much about painting. I came here to-day feeling that I would get some information that would settle a great many questions, and I hope that Mr. Sherman will give us, at some future date, some information on painting standpipes. I believe that, at the present time, it is one of the things regarding which we have very little information.

PRESIDENT DAVIS. Then we will pass to the next paper, — "Small Pumping Engines," by Mr. Symonds.

Mr. Symonds then presented his paper, which was discussed by President Davis and Messrs. Frank L. Fuller, Samuel A. Agnew, J. Harold Hayes, F. H. Hayes, Bertram Brewer, A. O. Doane, Reeves J. Newsom, T. G. Hazard, Jr., C. W. Fulton, and Leonard Metcalf.

Owing to the lateness of the hour, the further consideration of the report of the committee on frozen water services was postponed until some subsequent meeting.

Adjourned.

ANNUAL MEETING.

HOTEL BRUNSWICK, BOSTON,
January 8, 1919.

The President, Carleton E. Davis, in the chair.

The following-named members and guests were present:

HONORARY MEMBERS.

E. C. Brooks.	R. C. P. Coggeshall.	F. E. Hall.
	F. P. Stearns. — 4.	

MEMBERS.

S. A. Agnew.
L. M. Bancroft.
W. T. Barnes.
H. K. Barrows.
G. W. Batchelder.
A. E. Blackmer.
J. W. Blackmer.
George Bowers.
Bertram Brewer.
H. B. Burley.
J. C. Chase.
F. L. Cole.
W. R. Conard.
John Cullen.
F. A. Darling.
C. E. Davis.
J. H. Dillon.
J. M. Diven.
A. O. Doane.
J. N. Ferguson.
S. F. Ferguson.
Patrick Gear.
H. T. Gidley.
H. J. Goodale.
F. W. Gow.
F. M. Griswold.
T. G. Hazard, Jr.
Allen Hazen.
D. A. Heffernan.
J. L. Howard.
W. F. Howland.
J. A. Hoy.
J. W. Kay.
E. W. Kent.
Willard Kent.
J. A. Kienle.
S. E. Killam.
H. O. Lacount.
T. E. Lally.
G. H. Leland.
P. J. Lucey.
D. B. McCarthy.
F. A. McInnes.
W. A. MacKenzie.
H. V. Macksey.
F. A. Marston.
J. H. Mendell.
C. W. Mills.
H. A. Miller.
F. L. Northrop.
A. E. Pickup.
L. C. Robinson.
P. R. Sanders.
J. W. Smith.
G. H. Snell.
H. A. Symonds.
A. H. Tillson.
D. N. Tower.
W. E. Whittaker.
H. F. P. Wilkins.
F. E. Winsor. — 61.

ASSOCIATES.

Bond, H. L. Co., by F. M. Bates and F. M. Matthies.
BuildersIron Foundry, by A. B. Coulters.
Byers, A. M., Co., by H. F. Fiske.
Central Foundry Co., by R. W. Conard.
Donaldson Iron Co., by C. F. Glavin.
Eddy Valve Co., by H. R. Prescott.
Edson Mfg. Co., by H. L. B. Watson.
Fire and Water Engineering, by C. B. Hayward.
Hayes Pump and Machinery Co., by F. H. Hayes.
Hersey Mfg. Co., by J. H. Smith.
Lead Lined Iron Pipe Co., by T. E. Dwyer.
Ludlow Valve Mfg. Co., by A. R. Taylor.
National Meter Co., by J. G. Lufkin.
National Water Main Cleaning Co., by B. B. Hodgman.
Neptune Meter Co., by H. H. Kinsey.
A. P. Smith Mfg. Co., by F. L. Northrop.
Thomson Meter Company, by E. M. Shedd.
Union Water Meter Company, by H. W. Jacobs.
United Brass Mfg. Company, by G. A. Caldwell and W. N. Fairfield.
Wood & Company, R. D., by E. J. Lame.
Worthington Pump and Machinery Corp., by Samuel Harrison and W. F. Bird. — 24.

GUESTS.

NEW HAMPSHIRE.
Manchester, Frank Dill and George Woolner.

MASSACHUSETTS.
Cohasset, L. T. Litchfield.
Holyoke, Frank M. Livingstone.

NEW YORK.
New York City, S. Willard Jacobs and G. C. Northrop.
Woodhaven, James Cochran. — 7.

At the request of President Davis, after calling the meeting to order, all present rose and remained in most impressive silence with bowed heads, as a tribute to the memory of ex-President Roosevelt. Then the Secretary read the following resolution, reported by the Executive Committee:

"The New England Water Works Association hereby records its deep sense of loss in the death of Theodore Roosevelt, former President of the United States and a typical American. His strong and vigorous manhood and extraordinary range of activities brought him frequently in touch with the interests of this Association. As individuals we are grieved, and as an organization we feel his passing keenly."

On motion of Mr. James H. Mendell, it was voted that the resolution be adopted and published in the JOURNAL.

The Schumaker-Santry Company, Boston, power-plant equipment engineers, was elected to associate membership.

The Secretary, Mr. Willard Kent, submitted the following report:

REPORT OF THE SECRETARY.

JANUARY 1, 1919.

Mr. President and Gentlemen of the New England Water Works Association, — The Secretary submits herewith the following report of the changes in membership during the past year, and the general condition of the Association.

The present membership is 905, constituted as follows: 13 Honorary, 815 Active, and 77 Associate Members, there being a net loss for the year of 97. The detailed changes are as follows:

MEMBERSHIP.

January 1, 1918.	Honorary Members	14	
	Died	1	
			13

January 1, 1918.	Total Members		901		
	Withdrawals:				
	Resigned	54			
	Dropped	42			
	Died	16			
		—	112		
			—	789	
	Initiations:				
	February	4			
	June	3			
	September	5			
	November	4			
	December	4			
		—	20		
			—	20	
	Reinstated:				
	Member dropped in 1913	1			
	Members dropped in 1917	4			
		—	5		
	Elected 1917, qualified 1918		1		
			—	6	
				—	815
January 1, 1918.	Total Associates		87		
	Withdrawals:				
	Resigned	7			
	Dropped	4			
		—	11		
			—	76	
	Elected 1917, qualified 1918			1	
				—	77
					—
January 1, 1919.	Total membership				905
January 1, 1918.	Total membership				1 002
	Net loss				97

The Secretary has received and paid to the Treasurer, $7 941.51.
Of this amount, the

Receipts for initiation fees were			$97.00
From dues of members	$3 314.13		
From dues of members, fractional	15.00		
From dues of members, past	15.25		
	———	$3 344.38	
From dues of Associates	$1 620.00		
From dues of Associates, fractional	1.25		
	———	1 621.25	
		———	
Total from dues			4 965.63

From advertising	$1 815.00
From subscriptions	244.50
From JOURNALS	63.51
From sundries	755.87
Total as above	$7 941.51

There is due the Association at this date:

For advertising	$134.02

The outstanding bills against the Association amount to $1 007.36.

Respectfully submitted,

WILLARD KENT, *Secretary.*

REPORT OF THE TREASURER.

Mr. Lewis M. Bancroft, Treasurer, submitted the following report:

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$198.22
Initiation fees	$97.00	
Dues	4 965.63	
Total received from members		5 062.63
JOURNAL:		
Advertisements	$1 815.00	
Subscriptions	244.50	
Sale of JOURNALS	63.51	
Sale of reprints	127.87	
Sale of cuts	4.62	
Total received from JOURNAL		2 255.50
Miscellaneous Receipts:		
Sale of "Pipe Specifications"	$5.40	
Dinners	567.00	
Certificates of membership	6.00	
Buttons	1.50	
Meter rate slips	3.62	
June excursion	26.02	
Miscellaneous	7.44	
Total miscellaneous receipts		616.98
Total receipts		$8 133.33

LEWIS M. BANCROFT, *Treasurer*.
In account with the New England Water Works Association.

RECEIPTS.			EXPENDITURES.		
1918.			Bills paid		$8 280.89
Jan. 1. Balance on hand	$3 104.59		BALANCE ON HAND.		
Received of Willard Kent, Secretary,	7 941.51		People's Savings Bank	$2 000.00	
Interest on bonds and deposits	191.82		Mechanics Savings Bank	422.00	
			First National Bank	93.06	
			Liberty Trust Co.	441.97	
					2 957.03
	$11 237.92				$11 237.92

ASSETS AND LIABILITIES.

ASSETS.		LIABILITIES.	
Cash balance in banks	$2 957.03	Accounts payable	$0.00
Bonds Nos. 2642 and 2644 Lake Shore & Mich. Southern R. R., due May 1, 1931. Book value, $1 815.00. Market value	1 760.00	Surplus	4 851.05
Accounts receivable:			
Advertising	134.02		
	$4 851.05		$4,851.05

READING, January 6, 1919.

LEWIS M. BANCROFT, *Treasurer*.

Expenditures.

JOURNAL:			
Advertising agent's commission		$177.15	
Plates		45.23	
Printing		2 929.62	
Editor's salary		300.00	
Editor's expense		31.36	
Reporting		224.70	
Reprints		372.25	
Envelopes and postage		22.70	
			$4 103.01
Office:			
Secretary's salary		$200.00	
Secretary's expense		24.75	
Assistant to Secretary		1 170.00	
Assistant to Secretary, expenses		139.57	
Rent		550.00	
Printing, stationery, and postage		295.17	
			2 379.49
Meetings and Committees:			
Reporting		$28.50	
Stereopticon		94.70	
Dinners	$730.70		
Cigars	10.00		
Music	16.00		
		756.70	
Printing, stationery, and postage		328.46	
Badges		36.34	
Rent		45.00	
			1 289.70
Treasurer's salary and bond			67.50
Certificates of membership			3.60
Water-waste posters			275.00
Dues of members in service			136.00
Flowers			18.00
Income tax			8.59
			$8 280.89

Report of Auditing Committee.

Mr. Bertram Brewer presented the following report of the Auditors:

Boston, Mass., January 8, 1919.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers. Respectfully submitted,

GEORGE A. CARPENTER,
EDWIN L. PRIDE,
BERTRAM BREWER,
Auditing Committee.

On motion it was voted that the reports of the Secretary, Treasurer, and Auditors as read be accepted.

Report of the Editor.

(Not read before Association.)

January 15, 1919.

To the New England Water Works Association, — I present the following report for Journal of the New England Water Works Association for the year 1918

The accompanying tabulated statements show in detail amount of material in the Journal.

Size of Volume. — The volume contains 557 pages, a reduction of 251 pages from that of 1917, which was the largest ever published.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge.

Circulation. — The present circulation of the Journal is:

Members, all grades	905
Subscribers	84
Exchange	21
Total	1 010

a decrease of 102 from the preceding year. Journals have been sent to all advertisers.

Advertisements. — There has been an average of 28 pages of paid advertisements with an income of $1 972.50, a slight increase over last year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the value of $5.50 have been sold. The net gain up to a year ago had been $316.65, so that the total net gain from this source to date is $322.15. There are 139 copies of specifications on hand, $13.90 worth if sold at retail.

The Association has a credit of $12.55 at the Boston Post Office, being the balance of money deposited for payment of postage upon JOURNAL at pound rates. The following tables are for Volume XXXII, not for the calendar year, and receipts and expenditures show total charges and accounts payable with no reference to amounts actually received or disbursed.

TABLE 1.

STATEMENT OF MATERIAL IN VOLUME XXXII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1918.

Number.	Date.	Pages of								Total Cuts.
		Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Inset Plates.	Total.	
1	March	102	18	120	.	32	4	.	156	17
2	June	61	7	68	.	32	4	1	105	1
3	September	91	18	109	.	33	4	1	147	1
4	December	92	8	101	5	32	4	7	149	27
	Total	346	51	398	5	129	16	9	557	46

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXXII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1918.

Receipts.		*Expenditures.*	
Advertisement	$1 972.50	Printing JOURNAL and mailing	$1 847.88
Sale of JOURNALS	63.51	Printing illustrations	304.00
Sale of reprints	127.87	Preparing illustrations	120.66
Sale of cuts	4.62	Editor's salary	300.00
Subscriptions	252.00	Editor's incidentals	6.36
	$2 420.50	Advertising agent's salary and commission	118.40
Net cost of JOURNAL	694.50	Reporting	224.70
		Reprints	193.00
	$3 115.00		$3 115.00

TABLE 3.

Comparison between Volumes XXI to XXX, Inclusive (omitting Volume XXXI), New England Water Works Association.

	Vol. XXII. 1908.	Vol. XXIII. 1909.	Vol. XXIV. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.	Vol. XXVII. 1913.	Vol. XXVIII. 1914.	Vol. XXIX. 1915.	Vol. XXX. 1916.	Vol. XXXII. 1918.
Average edition (copies printed)	1 000	1 000	1 150	1 000	1 000	1 000	1 050	1 325	1 500	1 388
Average membership	699	710	732	752	740	745	803	904	1 002	954
Circulation at end of year	780	802	827	840	826	858	951	1 079	1 155	1 010
Pages of text	500	459	643	475	401	554	564	596	538	398
Pages of text per 1 000 members	715	646	880	632	542	746	702	659	538	417
Total pages, all kinds	681	627	808	654	567	733	719	776	707	557
Total pages per 1 000 members	976	884	1 090	870	766	984	895	859	707	584
Gross Cost:										
Total	$2 733.61	$3 111.15	$3 490.81	$2 625.87	$2 476.55	$3 586.29	$3 345.87	$4 243.35	$3 386.63	$3 115.00
Per page	4.01	4.97	4.32	4.02	4.37	4.89	4.65	5.47	4.79	5.59
Per member	3.91	4.39	4.78	3.50	3.35	4.81	4.17	4.68	3.38	3.26
Per member per 1 000 pages	5.88	7.00	5.90	4.09	5.90	6.46	5.80	6.02	4.79	5.85
Per member per 1 000 pages text	8.02	9.56	7.44	7.36	8.35	8.68	7.39	7.85	6.30	8.19
Net Cost:										
Total	$131.06	$789.98	$1 334.06	$352.82	$98.81	$1 322.90	$1 155.33	$2 091.09	$1 171.98	$694.50
Per page	.19	1.26	1.65	.54	.17	1.80	1.61	2.70	1.65	1.25
Per member	.19	1.11	1.82	.47	.13	1.78	1.44	2.32	1.17	.73
Per member per 1 000 pages	.28	1.78	2.25	.55	.23	2.42	2.00	2.98	1.65	1.31
Per member per 1 000 pages text	.39	2.43	2.83	.98	.33	2.38	2.55	3.88	2.17	1.83

Reports of Committees.

Standard Specifications for Cast-Iron Pipe.

President Davis. Is there any report from Mr. McInnes or any member of the Committee on Standard Specifications for Cast-Iron Pipe?

Mr. Conard. In the absence of Mr. McInnes, the committee can only say that, due to the war conditions, there is nothing but progress to report.

Standard Specifications for Fire Hydrants.

Mr. H. O. Lacount. At the meeting in April, 1914, which was a special meeting, the hydrant specifications were adopted in part, but certain items, regarding which there were questions, were referred back to the committee for further consideration. I wrote to the manufacturers regarding one item, which was the matter of the friction loss, to obtain from them data regarding their own hydrants. I did not get any information from them at that time, and as a matter of fact I have not yet, but for reasons which will appear I did not follow up my first letter, so that we won't lay too much blame at the door of the manufacturers, because they have been very busy. Then, a little later, the war broke out and the manufacturers generally, including the hydrant manufacturers, were increasingly busy from that time practically to the present, and it seemed to be rather inadvisable to bring up the matter of revision of the specifications, which might lead to a demand for different construction or design from what they were putting out at the time. Consequently the matter was allowed to rest.

But since the armistice has been signed, and since the Secretary said that now was the time to go at it again, I just want to say, as a matter of progress, that the particular points which were referred back to the committee are now again before the committee and that we are very hopeful that in due time we may have something specific to offer again for your consideration. It has, however, seemed, at least to the chairman, — and I have not yet heard from the other members of the committee, — that it

would be advisable, in view of the importance of these items which are to be considered, that the suggestions of the committee be bulletined to the members of the Association, so that the members may see in advance exactly what is proposed and be better prepared for discussion when the matter is finally before the Association in an open meeting. That we shall probably do, and, therefore, you will be advised in advance when the matter is to come before you again, with the idea that we may then finish the work which was begun some time ago. This I would suggest, therefore, as a progress report.

PRESIDENT DAVIS. Is there any discussion of this progress report?

MR. J. M. DIVEN. Do I understand that the committee has a printed report on these three items which are under discussion, which will be published?

MR. LACOUNT. We haven't the report yet completed. There are certain suggestions which are now before the committee. The committee has not had a meeting, and therefore the members are not even prepared to announce their own ideas on these points. The thought was that, rather than bring in a report which would not have advanced consideration, it was well not only to take the matter up with the manufacturers, which we naturally would do anyway, before sending out our report, but also to bulletin it to the Association members so that they might have an opportunity to consider it in advance of final discussion.

On motion it was voted that the report be accepted and placed on file as a progress report.

Statistics of Water Purification Plants.

(George C. Whipple, Chairman.)

The Secretary read a letter from Mr. Whipple, in which he said:

"I am sorry to say that we are not yet able to report, as the war has prevented all work of the committee during the past year. Will you be good enough to consider this as a request from the committee for a further extension of time."

PRESIDENT DAVIS. I take it that there is no objection, and the request will be granted and the committee continued.

Leakage of Pipe Joints.

(F. A. Barbour, Chairman.)

PRESIDENT DAVIS. Mr. Barbour is not here, but the Secretary has a letter from him which he will read.

The Secretary read the following letter:

NEW ENGLAND WATER WORKS ASSOCIATION,
WILLARD KENT, *Secretary:*

Dear Sir, — Replying to yours of December 18, in reference to report of the Committee on Leakage of Pipe Joints, I have to inform you that during the past year no work has been done by this committee, and no report will therefore be available for the annual meeting of the Association. Future progress in the investigations of this committee depend on experimental work, involving the employment of mechanics and laborers, and conditions during the past year have not been favorable for such an undertaking.

Yours very truly,

F. A. BARBOUR.

PRESIDENT DAVIS. I think Mr. Barbour ought to have some new associates on his committee. I happen to be one member of the committee, and I know that I have done nothing except make promises which have not been fulfilled. Some of those promises were in connection with the mechanical work which Mr. Barbour suggested. He outlined a very interesting series of experiments, and I think some of them may go forward within the next few months.

Standard Specifications for Meters.

(Charles W. Sherman, Chairman.)

MR. SHERMAN. The committee has not been able to hold a meeting during the year, but there has been some correspondence between the members, and some data have been accumulated in written form, so that we can report progress in a technical sense, although the amount of progress has not been very great. We hope with the cessation of war-time activities we shall all have a little more time to give to professional subjects, and that we shall be able to accomplish something more tangible during the coming year.

Revenue from Fire Services.

(W. C. Hawley, Chairman.)

The Secretary read the following letter:

DECEMBER 20, 1918.

MR. WILLARD KENT, *Secretary*,
NEW ENGLAND WATER WORKS ASSOCIATION,
715 TREMONT TEMPLE, BOSTON, MASS.

Dear Sir, — Replying to yours of the 18th inst., would say that the Committee on Revenue from Fire Services has not had a meeting owing to conditions brought about by the war and the absence of Mr. E. V. French in France. I am very sure, however, that the individual members of the committee have the matter in mind, and that when we are able to meet it will be found that substantial progress has been made, and we shall hope to be able to make a report to the next convention.

The matter of rates for private fire protection is coming more and more to the attention of the public service commissions and is being studied by them, and I think that we may hope for some decisions which will be helpful in the near future. In my own case I know that I have been having some experience within the last two years on this subject which has led me to change my mind quite materially on the question of how and what sort of charges should be made for private fire protection.

Yours very truly,

W. C. HAWLEY.

PRESIDENT DAVIS. I suppose the committee will be continued.

Frozen Service Pipes.

(Frank J. Gifford, Chairman.)

PRESIDENT DAVIS. There ought to be considerable discussion of this, because it has been up once or twice and is unfinished business. Mr. Gifford is not here, but Mr. Lally is present.

MR. THOMAS E. LALLY. The committee has nothing further to report at the present time. The matter has been dragging along ever since the September meeting, and we have hoped that somebody would get up and start something, but nobody seems to care to do it. If any of the members here would like to have any information which the committee can give, we would be glad to give it.

MR. D. A. HEFFERNAN. I would like to have this matter go over until the next meeting and have it advertised for that meeting, because there are not many superintendents here to-day. If it can be advertised as one of the matters for discussion at the February meeting, then perhaps the superintendents will come in and tell us their experience during the last winter.

PRESIDENT DAVIS. I think the committee ought not to be disappointed because of the lack of discussion of their report; in fact, I think it is a compliment to them, and it is because their treatment of the subject was so full and complete and their investigations so comprehensive that I believe the members feel that by going to the report they can find almost any question answered. I know that has been my thought on the subject, and I presume it has been that of a great many, that the committee had covered the subject so comprehensively there could not much more be said.

Priorities.

(Willard Kent, Chairman.)

MR. WILLARD KENT. Your Committee on Priorities, appointed June 19, 1918, to protest in behalf of the Association against the classification of the manufacture of meters and other waterworks supplies as non-essential industries, find themselves unable to make even a progress report. President Davis of our Association had previously been appointed on a committee from the American Water Works Association on the same subject, and our committee was appointed to work in conjunction with them.

As the result of his initiative he advised us that "it is absolutely useless to interview the Priorities Board on any general matter. They will take up specific cases, but absolutely decline to interest themselves in general matters. Any attempt to secure action along general lines is impracticable."

The New England Preferred List of Industries and Plants, issued September 3, 1918, placed public utilities in Class 2, a much more liberal classification than those which had preceded it.

As you know, the committee and the Association suffered a great loss in the death of Mr. William F. Woodburn, who with

Mr. Seth D. Higley had recently been added to the committee. A letter written by Mr. Woodburn three days before his death emphasizes his deep interest in the Association, of which those who had the pleasure of his intimate acquaintance are so well aware. It is as follows:

BOSTON, MASS., September 12, 1918.

MR. WILLARD KENT,
NARRAGANSETT PIER, R. I.

Dear Mr. Kent, — I understand that I have been appointed on your Priorities Committee and am disregarding the formality of waiting for notification of this appointment to write you that if it is the intention that this committee get results, I am with you, as what we accomplish will be a great benefit not only in New England, but all over the United States of America.

It will mean *quick, forceful* action, with lots of hard work, and the backing of the Association on any action the committee may consider wise; but result will be worth it.

Kindly advise me what has been done by the committee to date.

Sincerely,

WM. F. WOODBURN.

201 DEVONSHIRE STREET,
BOSTON.

I am pleased to say that it is the belief of your committee that the exigencies which called for its appointment are past, and that there is now no good reason for its continuance.

WILLARD KENT, HIRAM A. MILLER,
A. E. MARTIN, SETH D. HIGLEY,
WM. F. WOODBURN,
(Deceased.)
Committee on Priorities.

PRESIDENT DAVIS. I take it that a motion to accept the report and discharge the committee will be in order.

On motion it was voted that the report be accepted and the committee discharged.

THE DEXTER BRACKETT MEMORIAL MEDAL.

PRESIDENT DAVIS. The award of the Dexter Brackett medal is the next matter of business. The Secretary will announce the action of the Executive Committee.

THE SECRETARY. The Executive Committee at its meeting

to-day voted to award the Dexter Brackett memorial medal for the year 1917 to Mr. Albert L. Sawyer, water registrar, Haverhill, Mass., for his paper entitled, "Some Advantages of Classified Cash Books."

PRESIDENT DAVIS. Mr. Sawyer is not here this afternoon, and it was not the intention to make the presentation at this time, but merely to indicate the action of the committee. I presume Mr. Sawyer will be here at the February meeting, and we will make the presentation then. I want to express my gratification that the award has been made to Mr. Sawyer, and that it has been made for a paper of this particular character.

(Later in the afternoon the newly elected President, Mr. Killam, announced that the Executive Committee had appointed as a committee to award the Dexter Brackett medal for the year 1918, William T. Barnes, William F. Sullivan, George W. Batchelder. The committee will report before August 1, 1919.)

ADDRESS BY THE RETIRING PRESIDENT.

PRESIDENT DAVIS. In entering on the period of reconstruction a glance backward over the era of war is not unnatural. None of us proposes to linger unduly or be diverted from the immediate problems of the future, but a reasonable view backwards may be an inspiration for what is ahead.

Water-works officials may feel legitimate pride that the utilities under their direction responded generally to the public necessities in a satisfactory way. Probably no other function, essential for the prosecution of the war, suffered fewer breakdowns and caused less concern to the consumer than did the water supplies, notwithstanding that water works, equally with other public-function activities, were handicapped by the general difficulties of the situation. These results were the operator's contribution to the general cause, and the outcome testifies to the fundamental soundness of the water-works plants of the country.

The period of reconstruction — physical, mental, moral, and financial — now comes. We have all drawn on our capital resources, whether invested in plant which has deteriorated by accel-

erated depreciation, or held in some other form. It is universally held that fundamental changes are at hand, and various opinions as to what the future will develop may be had for the asking. Definite predictions at this time are largely valueless; but we all know that when materials are in a state of flux, the opportunity of the molder is at hand. Out of the present situation will come whatever those who are able to form and direct may desire.

Our Association has passed through the war without material change or without suffering serious loss in numbers or resources. We have had no opportunity to perform conspicuous public service as a body, but through individual members and through the uniquely essential works which those members represent, the Association has rendered indispensable help.

It is not out of place to repeat the statement previously made, that the country was notably prepared for war in sanitary science and military public health activities in which this Association has performed sound pioneer work.

Reconstruction will affect this Association as a body, as well as the utilities which its members control. As a body of men we definitely control the future of our own Association and can shape its course as we choose. In the future, as in the past, the New England Water Works Association will be guided by men of wide vision who will lead and not follow, and we may look forward with confidence in the certainty that this Association will maintain its preëminent position. But changes are inevitable, and the Association will not wait for outside influences to take the initiative; rather it will shape its course in such a way as to be in the forefront of new thought and activities.

Suggestions and recommendations will be premature, but thoughts expressed out loud may not be inopportune. Our Association has a unique position in reasonable centralization of membership, frequent meetings, and permanent headquarters. Greater advantage will doubtless be taken of this situation, and the headquarters organization developed in a way to render larger return to the membership.

We have the opportunity of assuming a commanding position as the recognized center of water-works data and information. The Association will grow according to the service it renders.

There is an opening for a new field of usefulness in the development of the headquarters force so that any person, anywhere, desiring information on water-works subjects will think naturally of the New England Water Works Association as the source to which to apply. Such service would bring returns in increased membership, wider circulation of the JOURNAL, and greater advertising value for its pages.

The Association has always been notable for the freedom and frankness of discussion at its meetings, such freedom being caused by the knowledge that the Editor is a judicious reporter. The JOURNAL has the reputation of being the most sound and practical publication of its kind, truly reflecting the nature of the organization.

Perhaps the younger members are not heard from as frequently as desirable, and the well-worn formula that the young members must be encouraged is often heard. There is a natural gravitation of one age to a like age, and it may be that there has been an undue representation of the members of maturer years in the management of the Association, who may lack the necessary acquaintance among the younger men to bring out all their possibilities. I feel sure I voice the unanimous desire of all when I commend to all members, younger or older, the overcoming of any reluctance to offer whatever they have in mind at any time, with the assurance that it will be heartily welcomed. The Association follows the advice of Saint Paul to the Thessalonians, to try all things and retain that which is good.

The old-fashioned experience meetings are typical of the spirit of this Association. They were good for the soul and good for the mind, and personally I hope it will be found proper to develop and increase their number. They have been the means of placing at the disposal of the general water-works practitioner a vast fund of invaluable information concerning ways and means, and at the same time they have furnished a wonderful safety valve for pent-up feelings. True, there is an outlet for such feelings in conversation with fellow-members during the social periods incident to the meetings, but not all members can attend the meetings, and even reading about the other man's troubles is often a great relief.

Possibly the future may develop periodical meetings conducted by the associates, — meetings at which the present practice will be reversed and the associates talk while the members listen. It may be that the associates are now obtaining an undue advantage in listening to the views of the members, pro and con, without being obliged to commit themselves to any line of action. On the other hand, perhaps the members are not availing themselves of an opportunity to hear a frank discussion between the various makers of the articles in everyday use by the waterworks operator. Nothing could be more enlightening than a free discussion between makers of competitive goods, and doubtless such discussions could be brought about without detriment to any and with profit to all, apart from the features that may savor of competition. There are likewise vast funds of useful information in regard to fundamentals at the command of the associates which could profitably be placed at the disposal of the Association.

This same principle might be carried further with advantage, and associates be given membership on committees investigating subjects in which the associates are vitally interested. Such a procedure would give the opportunity for a minority report, if such should be necessary, and thereby tend to the more complete enlightenment of the Association on all phases of any particular subject.

One change which has already been effected by the war, and at the instance of this country, is open diplomacy and the adoption of perfect frankness in discussion. In following these lines the Association will doubtless reconstruct the present rather indefinite financial status of the associates. From dues and through advertising, the Association derives about one half of its income from the associates, and for the conventions accepts or solicits contributions for entertainments and hospitality. This is not done solely as a matter-of-fact business transaction, nor do the associates make such contributions solely because of their personal regard and esteem for the members. The business factor is tempered by the fact that the association furnishes a medium through which personal relations are developed to the mutual advantage of both parties having business to transact with each

other. This is the case, and the situation should be frankly recognized and put on a definitely understood basis.

A notable recognition of the wide range of activities embraced within the membership of this Association is the award of the Brackett memorial for a paper devoted to accounting. The water-works operator has been too often classified as a specialist on pumps, pipes, reservoirs, or some similar matter, while in fact he is responsible for not only the operation of highly specialized machinery but he is further charged with the conduct of large business interests. By its own action, the Association now lays claim to this larger sphere of operations, and asserts the proper standing of its members in the community.

The annual convention in 1918 was on a strictly war-time basis, without special entertainment and without the customary exhibits. An innovation in the way of poster advertising urging the reduction of waste as a means of saving coal was an accompaniment of the convention which attracted considerable attention. The idea of saving coal by this method was taken up and expanded by the national Fuel Administration.

I have purposely refrained from any extended or detailed enumeration of events of the past year for the past at this period is behind us in an entirely new sense, and we are at the beginning of an entirely new era to which we are looking ahead with confidence.

Election of Officers.

Mr. Thomas E. Lally presented the following report of the tellers appointed to canvass ballots for election of officers:

Whole number of ballots	246
Blanks	1
President.	
Samuel E. Killam	244
Vice-President.	
Henry V. Macksey	240
Charles W. Sherman	242
Percy R. Sanders	241
Frank A. Barbour	239

Thomas McKenzie	241
James H. Mendell	240
Secretary.	
Willard Kent	242
Treasurer.	
Lewis M. Bancroft	242
Editor.	
Henry A. Symonds	244
Advertising Agent.	
Henry A. Symonds	241
Additional Members Executive Committee.	
Frank J. Gifford	240
A. R. Hathaway	240
Patrick Gear	236
Scattering	1
Finance Committee.	
George A. Carpenter	240
Edwin L. Pride	239
Frank A. Marston	238

(Signed) THOMAS E. LALLY, *Chairman.*
W. E. WHITTAKER.

President Davis thereupon declared the following to have been elected officers for the ensuing year:

President, Samuel E. Killam.

Vice-Presidents: Henry V. Macksey, Charles W. Sherman, Percy R. Sanders, Frank A. Barbour, Thomas McKenzie, James H. Mandell.

Secretary, Willard Kent.

Treasurer, Lewis M. Bancroft.

Editor, Henry A. Symonds.

Advertising Agent, Henry A. Symonds.

Additional Members Executive Committee: Frank J. Gifford, A. R. Hathaway, Patrick Gear.

Finance Committee: George A. Carpenter, Edwin L. Pride, Frank A. Marston.

President Davis then called the new President to the chair.

Address by President Killam.

Mr. President and Fellow-Members of the New England Water Works Association,—I am honored and I greatly appreciate the honor of being elected President of this Association.

In sharing the honors and the responsibilities of the management of the Association with its newly elected officers permit me to request that the same good-fellowship and hearty coöperation, for which this organization is noted, be continued throughout the coming year. Individual efforts are commendable, but without the constant coöperation of the membership we cannot reach the effective and successful end that is desired.

Now, with the record of the great war behind us — a record of which we all are justly proud — let us welcome back our members and face the reconstruction work with renewed vigor. We each have a duty to perform, and one which as managers, superintendents, engineers, and manufacturers we owe not only to ourselves and to the communities we serve but to the general public. Therefore let us meet this duty squarely, with a firm and steadfast resolution to overcome the delays that have been inevitable during the past year. Well have your water supplies been guarded, and great credit is due to the measures taken to preserve and safeguard the public health during the past troublous months; and may the lessons learned be given, in due time, to the fraternity, so that mutual benefit may be derived from your experiences in planning reconstruction and extension of the present works or the laying out of new supplies.

To the active members I would say that the future of the Association is in your hands. It is your duty to continue this organization as the leading power which it has always maintained in the water-works fraternity. Let us therefore work together to carry out those high ideals that are ours by inheritance, lest some similar society replace our standard by actual achievements. I ask the members, irrespective of profession, to volunteer for active service in order that our higher ideals may be put into action. If volunteers fail us it may be necessary to resort to selective draft in order to secure papers and membership on committees.

To the members that have been long in service I extend a most cordial greeting, and beg you to tarry with us that we may have the benefit of your long and varied experiences. The Association needs your counsel as much to-day as it did years long ago, so that the high standard which you have set may be maintained in the future.

May the associate members, who have always shown the highest regard for this body, continue to exercise the same influence for building up this Society in the future as in the past, so that the founders — who builded better than they knew — may look with pride on the good-fellowship and hearty coöperation which has always existed between the active and associate membership.

I congratulate you on the personnel of the officers who have been elected to serve with me during the coming year. In every live organization there will always be differences of opinion as to management. A free and frank discussion of such differences will be very beneficial in administrating the affairs of the Association. Let us enter upon our duties with open minds and with firm determination to carry on the work for higher ideals, better service, and in the best interests of the New England Water Works Association.

Is there anything further to be brought before the Association at this time?

MR. HENRY A. SYMONDS. Mr. President, at the beginning of a new year it is proper that we should look into all Association matters, and if possible inaugurate new and improved methods for the coming twelve months.

With this in view, I wish to call attention of the Association to what seems to me to be an obligation of the members of this Association towards the advertisers in the JOURNAL, which you have been kind enough to place in my hands for another year.

It seems evident that for all firms and individuals furnishing supplies, or doing business in any way relative to water works, there is no medium in this section of the country which fills the needs of a good advertising medium equal to the New England Water Works Association JOURNAL.

There have been occasional complaints that the advertising by the associate members was rather to help along the Association than because of the value they placed upon the "ads."

I am convinced that this is not the point of view taken by most, if not all, the advertisers, and that on the contrary they consider it a good business proposition.

On the other hand, it is evident that their "ads" can be made still more desirable and valuable by the attention of the members

of the Association to this matter, and I believe it is an obligation upon the members to give especial attention to the list of advertisements.

There is, of course, no obligation to pay higher prices, because the advertisements have been taken, but if the members will give a greater amount of attention to the advertisements, their value will be correspondingly increased.

I hope that during the coming year all subscribers to the JOURNAL will make it a point to familiarize themselves with the "ads." more carefully than ever before, so that our JOURNAL may become recognized to a still greater extent as the leading advertising medium for all water-works supplies.

I am sure you will cordially coöperate along this line.

PRESIDENT KILLAM. Anything further to be said for the good of the Association?

MR. ALLEN HAZEN. Your Committee on Meter Rates was discharged two years ago, but there have been some happenings since which may be of interest to members of the Association. The form of water rates that was adopted by the Association has been put into effect by the Hackensack Water Company, supplying several hundred thousand people in the state of New Jersey; and during the past year it has been put into effect by the Spring Valley Water Company in San Francisco with some 70 000 services and by the East Bay Water Company, supplying Oakland, Berkeley, and Alameda, also with some 70 000 services; and the rate established by the Railroad Commission was in the general form, although not the exact form, of the Association's rate. Mr. Sherman tells me, also, that the rates in that form have been adopted in Middletown, Conn. So rates in the Association's form have been adopted and are in use to-day by a population in excess of a million people. That is quite a progress report, I think, and I am glad to make it to the Association. [Applause.]

MR. CARLETON E. DAVIS. I think perhaps some members of the Association might be interested in this: At the time of the annual convention, when the subject of locating underground leaks was up, I mentioned a certain contrivance which one of the Philadelphia Water Bureau men devised. Since that time he has developed it rather extensively. So far as I know,

it is an enlargement of the stethoscope. The machine sells for about ten dollars, and thus far it has proven very successful. It is about the shape and size of the receiver of a telephone, with a little projection at the bottom to place on the ground or other listening point, and it has a tube with two branches, one of which can be inserted in each ear, and it has given some rather remarkable results not only in locating leaks but in locating the position of unknown underground pipes.

For instance, we were metering a certain building which had been erected some seventy-five years. It had no cellar, and there was one known service pipe. It was surrounded on three sides by streets, and when the service which was known and which was metered was shut off there was still water inside the building, so it was desirable to find the pipe. This listening device was placed on a spigot in the back yard, and then a man with a crowbar started to tap on the pavement above the mains surrounding the property on three sides. When he got to a certain point the sound was carried some one hundred feet to the listening point. It grew louder and louder, and then it died away, and at the point of the greatest sound they dug down and there was the missing service pipe. It appears to be rather an ingenious appliance, and one of the very nice things about it is that it is exceedingly cheap. It is portable, it can be put in your pocket, and apparently it can stand rough usage and is giving results.

Mr. J. M. Diven. Is the device on the market?

Mr. Davis. I think it is practically on the market. We have bought some ten or a dozen of them which have been made by hand; but there are dies now, so that they can be made in quantity.

Mr. Diven. Is it advertised in the Journal? [*Laughter.*]

Mr. Davis. No. I am not financially interested, of course, but I should like to see the man make a legitimate profit. Now if he does advertise in the Journal, how many will you buy? [*Laughter.*]

President Killam. We are always glad to hear from members from a distance. Mr. Hazen has spoken to us, and I see another man here from New York, Past President Smith. We would be very glad to hear from him. [*Applause.*]

Mr. J. Waldo Smith. I do not know that I have anything of interest to state to the meeting at this time. New York has had some difficulties in the last year. You all remember the conditions that were existing a year ago, when there was such an enormous consumption of water during the cold weather, and we felt then that it was most fortunate that the Catskill water had been delivered to New York a year in advance of that time. On the other hand, I think it was perhaps unfortunate that the people didn't have a little trouble, in order to bring them to a realization that the water was really needed, because even at the present time I think there are papers which defend the opinion that New York had water enough without the Catskill. But considering the fact that for a period of a year and nine months we have been using 425 million gallons a day of Catskill water, so that the Ashokan reservoir was depleted over 69 billion gallons, and the Kensico reservoir, which was always meant to be kept full except in times of emergency, was nearly half depleted, or about 12 billion gallons, the water-works people at least realize what a dreadful condition would have existed had Catskill water not been available. I don't think even the very serious condition which really existed at Jersey City, where they wouldn't even furnish water for the Erie Railroad, was any worse than it would have been in New York.

This condition of the Kensico reservoir was brought about by a very general increase of pressure all over the city, extending on the west side as far south as the Battery. In order to save as much pumping as possible, Catskill water has been used in excessive amounts to keep the pressure. But whereas the aqueduct will now deliver from the Kensico reservoir about 380 million gallons a day, the draft for a long period has been 425 or 450 million gallons a day, and in one period of the year it was over 500 million gallons a day, so they have been drawing the surplus out of the Kensico reservoir. Of course that cannot go on forever, and now by curtailing the waste and by pumping we hope to reduce the drawing from the Catskill so that the Ashokan reservoir in the course of a few years may fill up.

We all know from experience in our various water works how difficult a matter it is to educate the public — and public officials,

perhaps, more than the general public — to believe that some addition to the water supply is necessary; and still more difficult to induce them to grant to any administrative body sufficient authority so that a new supply can be developed with economy and with expedition. The Board of Water Supply is most fortunate that it has never found itself in the condition of the Public Service Commission who on the last day of the year were obliged to lay off from their working forces in the engineering department about 380 men at only an hour's notice, for the sole reason that through recent legislation they were tied to the Board of Estimates hand and foot. Not a salary could be increased, not a new position created, without an appeal to the governing body of the city, and the approval of the board of aldermen, and whereas this might and does work to some degree with a regular city department, whose business is somewhat uniform, it is an utter impossibility and will lead only to delay and expense with a commission such as the Public Service Commission building the new subway, or the Board of Water Supply which built the Catskill works.

Mr. F. H. Hayes. Mr. President, I am an associate member, and I have to ask the freedom of the floor.

President Killam. It is granted, Mr. Hayes.

Mr. Hayes. What I have to say has particularly to do with the associate members, and it relates to the subject of a certified check or a bidding bond. I endeavored to bring the matter before the Association two years ago, and it was placed on file, and I guess it has been on file ever since. The condition is this: We are asked to make prices for such material as we may be called on to furnish, and we have to put up either a bidding bond or a certified check. If we have several bids out, it ties up a considerable amount of money that is of no good to anybody. It loses interest the minute it leaves the bank, and it takes the chance of the bank not honoring the check if for any reason the bank should become insolvent. A bidding bond, which accomplishes the same object, comes from a responsible company and it is accepted.

Now, the question I want to get before this Association, and have tried to in the past, is for you to consider whether it is advisable to do, as the United States Government does, accept a

bidding bond, rather than to make us tie up money which becomes useless both to you and to us for a certain length of time. Sometimes it goes on for three months, and I have known of its going on for eight months. That is the reason I take this opportunity to bring the matter before the Association to see if we cannot have some action taken. I have talked to the associate members, and while they have agreed with me, they won't get up and talk about it; and if there is any way in which we can get it before one of our regular meetings as a subject for discussion I hope it will be done.

Mr. Carleton E. Davis. It seems to me this opens a very fruitful topic for discussion, and I think it is one which should be considered at some time in the near future. I think we might very well ask the Executive Committee to make it a topic for discussion, and I will make a motion to that effect.

It was voted to refer the matter to the Executive Committee, in order that it might be made a subject for discussion at a future meeting.

President Killam. I notice that another of our well-known members has come in, whom we are always glad to hear, and perhaps he will say a word to us, — Mr. Metcalf, ex-president of the Association.

Mr. Leonard Metcalf. *Mr. President and Gentlemen,* — I am rather taken back. I don't know quite to what subject you want me to address myself. The time of the Association is valuable, and I have not been here long enough to know what you have been considering to-day.

President Killam. We are interested in reconstruction work and would like it if you could give us something along that line.

Mr. Metcalf. I have been very much interested in the labor question, and its influence upon construction work at the present time; and I wonder somewhat what may be the opinion of the members of the Association present here to-day. It is very clear that at the present time considerable numbers of men, and women too, are being set adrift by the shutting down of the munition factories, and also by the gradual curtailment of work in certain lines of our staple industries, in a way which is likely to prove troublesome. I was in Schenectady, a week or ten days ago, and

found that the General Electric Company had shut off night work and overtime work, which had resulted in throwing, I don't remember the exact number, but thousands of employees out of their positions. I was told at the same time that various other works, like the American Locomotive Works, had shut down on their night work and were also curtailing in the output of their plant and cutting down the forces at work on day work. We are beginning to see it in this part of the country in growing measure, and we are face to face with the problem of furnishing permanent positions for the men returning from the front.

In this connection I might tell you a story about something that occurred in our office the other day, which amused me a good deal, and which bears a little on this question. My partner's son graduated a little more than a year ago from the Institute, and when the call was made for designers for service in the navy he took a special course given by Professor Peabody at the Institute, in naval architecture. Subsequently he went to New York and worked in the navy yard there, and then was ordered south to the Portsmouth, Va., yard, where he had charge of construction work. At the termination of the war he was face to face with a decision as to what he should do in the future. He came to New York and Boston and interviewed various men on his own initiative, and then at our suggestion, — and I think partly because his uncle was a representative of Kidder-Peabody,— he thought he would try banking, and we ourselves had the feeling that that would be a good field. So I gave him a letter to one of the partners of Estabrook and Company whom he went to interview. The gentleman very courteously gave him his time, told him about the conditions, and finally said that he felt very strongly it would be wiser for him not to go into the banking business, but to stay in the engineering business if he had been trained in that field, because, he said, in the first place, a great deal of the banking work had become highly commercialized, it was simply a commercial business, selling securities; and, in the second place, he said many of their men had gone to the front in response to the first call and others had been drawn in to take their places, and now these men were returning and would have to be placed, and they all felt that they ought to be placed.

Now, when you think of it, the humor of the situation lies in the fact that we as engineers were certain that the banking business was a desirable thing for a young man to go into, and a successful banker was quite certain that the engineering business was the thing. Everybody seemed to agree that the shipping industry, for which the young man had been specially trained or towards which his work would point, was likely to meet very, very serious difficulties under the Seamen's Act and the other limitations and demands of labor with which this Government is of course face to face. The shipbuilding industry is bound to let many men go in the near future, it seems to me, — it already has done so in certain yards, — and these men have got to get back to the normal industries.

The wage scale has not yet materially reflected the increase in the mobility of labor, or the increase in the supply of labor. Mill men say that they have already found that the question of getting labor is not so serious as it was, and that the general attitude of labor is changing with the increasing supply of labor, and they say that they believe that this will result in better conditions, lead to greater efficiency and a little better attitude, from their point of view, of labor generally. I cannot help feeling that we shall see a decline in the scale of wage, but there doesn't seem to be very much likelihood of decrease, particularly in the salaried positions, of permanent employees in water works, certainly not until there is a marked decline in the items which go to make up the cost of living, and those cannot well fall until after next summer, it seems to me, when the crops have been harvested, because of the very serious needs abroad; so that the readjustment in the intervening time of six or nine months promises to be a difficult one.

In this connection I was very much interested in the suggestion which a friend of mine made. He is an architect, and was interested in some work under the Housing Bureau. He had been revolving in his mind what could be done to make the conditions easier for labor, and this was his suggestion: Would it be possible in the building industry to make contracts through the labor organizations, on a basis which would presumably reflect fair current rates and would give organized labor the op-

portunity to get its wage? Then if it wished to work overtime or speed up the work, it would be perfectly possible for labor to increase its output by twenty-five or thirty per cent., and by working overtime to get a direct return within the time limit fixed for doing the work. In that way it would make it possible for labor to prolong the period of high return which it has been enjoying from overtime work, and at the same time benefit the person for whom the work was done, in that there would be greater certainty in the completion of the work, and that the very trying condition of having strikes towards the end and delays making it impossible to get into the building, would be avoided. I don't know that the scheme has been tried. Of course it is analogous to what used to be done years ago, when a man entered into a contract with a boss carpenter who got a lot of employees about him and did the work. But, of course, it is obviously open to the difficulty that, in doing that, organized labor would be taking a certain risk which it may feel it is not necessary for it to take. However, it is very clear from what has been going on and the statements of opinion that we have heard, that a great many men are thinking along the lines of what can be done to bridge over a very difficult situation. I think in a business way many of us are going to feel it much more in the coming six months than we ever have before, on account of the uncertainty which lies before us, and the fact that communities are not yet ready to go forward with confidence in ordering supplies and materials and doing work, because they expect that there will be lower rates of wages later. [*Applause.*]

Adjourned.

February Meeting.

Hotel Brunswick, Boston,
February 12, 1919.

President Samuel E. Killam in the chair.

The following-named members and guests were present:

Honorary Members.

E. C. Brooks.
R. C. P. Coggeshall.
Robert J. Thomas.—4.
George A. Stacy.

Members.

D. L. Agnew.
S. A. Agnew.
J. M. Anderson.
Lewis M. Bancroft.
Jesse F. Barrett.
Wm. T. Barnes.
H. K. Barrows.
Geo. W. Batchelder.
Henry F. Beal.
Arthur E. Blackmer.
J. W. Blackmer.
C. M. Blair.
Bertram Brewer.
John C. Chase.
F. L. Cole.
John H. Cook.
Fred A. Darling.
J. M. Diven.
Lewis R. Dunn.
Harrison P. Eddy.
E. D. Eldredge.
Frank Emerson.
Almon L. Fales.
Geo. H. Finneran.
Albert D. Flinn.
H. F. Forbes.
F. L. Fuller.
Patrick Gear.
H. G. Gidley.
Frank J. Gifford.
H. J. Goodale.
X. H. Goodnough.
J. W. Graham.
H. A. Hanscom.
L. M. Hastings.
T. G. Hazard, Jr.
D. A. Heffernan.
Charles R. Hildred.
A. B. Hill.
W. F. Howland.
Jos. A. Hoy.
Lt.-Col. G. A. Johnson.
Willard Kent.
S. E. Killam.
George A. King.
P. J. Lucey.
S. H. MacKenzie.
H. V. Macksey.
A. E. Martin.
J. H. Mendell.
Leonard Metcalf.
M. L. Miller.
H. S. Noyes.
Thos. A. Peirce.
Henry E. Perry.
Albert E. Pickup.
Albert L. Sawyer.
Walter P. Schwabe.
Charles W. Sherman.
Geo. H. Snell.
Henry A. Symonds.
E. J. Titcomb.
Lewis D. Thorpe.
Fred'k I. Winslow.—64.

Guests.

Massachusetts.

Plymouth, Fred D. Bartlett.
Somerville, Frank E. Merritt.

Arkansas.

Camp Pike, Mayo Hunter.
Harry J. Robinson, U. S. Navy.—4.

Associates.

Ashton Valve Co., by Harry H. Ashton.
Builders Iron Foundry, by A. B. Coulters and E. C. Steer.
Central Foundry Co., by P. W. Conrow.
Chapman Valve Mfg. Co., by J. T. Mulgrew.

Eddy Valve Co., by H. R. Prescott.
Hayes Pump and Machinery Co., by F. W. Hayes.
Hersey Mfg. Co., by J. Herman Smith.
The Leadite Co., by Geo. McKay, Jr.
Ludlow Valve Mfg. Co., by Arthur R. Taylor.
Metropolitan Water Works, by A. O. Doane.
H. Mueller Mfg. Co., by Chas. G. Haas.
National Meter Co., by G. Lufkin and H. L. Weston.
Neptune Meter Co., by N. H. McGarry, Jr.
Pittsburgh Meter Co., by G. C. Northrop.
Rensselaer Valve Co., by Chas. L. Brown and Irving A Rowe.
George H. Sampson Co., by W. T. Page.
A. P. Smith Mfg. Co., by F. L. Northrop.
Thomson Meter Co., by E. D. Higley and E. M. Shedd.
Union Water Meter Co., by H. W. Jacobs and Donald K. Otis.
United Brass Co., by Geo. A. Caldwell.
United States Cast-Iron Pipe and Fdry. Co., by W. P. Mosteller.
United States Rubber Co., by J. H. Learned.
Wallace and Tiernan Co., by H. K. Davies.
Warren Fdry. and Mach. Co., by H. K. Kinsey.
Water Works Equipment Co., by W. H. Van Winkle.
R. D. Wood & Co., by H. M. Simons.
Worthington Pump and Machine Corp., by Samuel Harrison, Willis F. Bird and E. P. Howard. — 34.

The Secretary announced that applications for membership had been received from A. R. G. Booth, Lowell, Mass., assistant chemist, Mass. State Department of Health; Thomas J. Carmody, Holyoke, Mass., water commissioner; George M. Graffam, Portland, Me., auditor for Portland Water District and Bangor Water Works; W. W. Nye, Fairfield, Me., real estate; A. B. Thompson, Waterville, Me., assistant superintendent, Kennebec Water District, — all properly endorsed and recommended by the Executive Committee.

On motion of Mr. Edwin C. Brooks, the Secretary was directed to cast one ballot in favor of the applicants, and, he having done so, they were declared duly elected members of the Association.

The Dexter Brackett Memorial Medal.

The President. The first matter on the program this afternoon is the presentation of the Dexter Brackett Memorial Medal to Albert L. Sawyer. Mr. A. D. Flinn will make the presentation.

Mr. A. D. Flinn. *Mr. President and Members of the New England Water Works Association,* — It is quite unexpected that this privilege should be mine to-day, but in coming into the meeting I was informed that the other members of the committee on the award were not here, the distant member, as sometimes happens, being present when the man who lives near by is not.

It is a genuine pleasure to be able to present this medal on this the second occasion of its award, not only because of the worthiness of the recipient, but because of my own very close intimacy with Dexter Brackett. When I first came to Boston as a youngster, a few years ago, it was with Dexter Brackett that I was very early associated, and it was with him that a very pleasant intimacy and friendship grew up, which lasted throughout the remainder of his life; and I see all around me men with whom I became acquainted through Mr. Brackett, — Mr. Coggeshall, for example, who sits here just before me. And so I was introduced to the New England Water Works Association by Mr. Brackett.

When Mr. Brackett finished his work among us, not so very long ago, it seemed most proper and pleasant that some token, some constant reminder of his work for this Association should be established. And you will remember that Mr. Brackett had a very high ideal as to the work of the New England Water Works Association, that it was to be helpful to various kinds of men, men engaged in various activities that were associated with it. And so it is a peculiar privilege in awarding the medal at this time to know that the Association is giving it to a man who has contributed to our work in a branch which sometimes, perhaps, we have failed to appreciate,— that branch of management and direction which deals with the accounts. It is therefore a peculiar pleasure to give to Mr. Sawyer, as the author of the paper on "Some Advantages of a Classified Cash Book," this medal. The paper, as you will remember, was presented at the Portland meeting in 1917, but, although it has taken so long to determine who was the worthy man, and to get the medal into your hands, Mr. Sawyer, please do not consider there was any lack of appreciation on our part of the value of your contribution to our Proceedings.

I now present to you this medal. [*Applause.*]

Mr. Albert L. Sawyer. I thank you very much for your

kind words, and I receive the medal with a great deal of pleasure. I have always thought that I should very much like a medal, but up to this time I have never been fortunate enough to secure one. At the time of the Civil War I was too young to go, and I was too old to go to the last one, consequently I have had to be content with tags and buttons. I don't know how it has been in your towns, but I will say that in my town I have been able to accumulate a large and varied assortment of them. [*Laughter.*] I should think that about everybody who was represented at the building of the Tower of Babel and on the day of Pentecost has had a drive in my town, to say nothing of such purely local affairs as the Blossoms of Zion, the Boy Scouts, and Rescue Mission.

I was greatly surprised when I received a letter from Secretary Kent announcing that I was to receive this medal. Of course personally I had no doubt that my paper was a most worthy one [*laughter*], but that the Committee on Award should say so, and the Executive Committee back them up, and thus make it unanimous, was really more than I had any reason to expect. One thing, leaving out the personal element, that has appealed to me is the fact that while the first medal was awarded to an engineer, the second has been awarded to a representative of the office department of water works, showing that this memorial trust is to be administered in the most catholic manner. And I have an idea, now that one water registrar has received this medal, every other water registrar will decide that he wants one, and I wouldn't be surprised if hereafter there were so many papers from registrars and treasurers that the engineers and superientendents will have to sit up and take notice, or we shall be carrying off all the honors. [*Laughter and applause.*] Knowing as I do the high reputation attained in engineering and water works administration by members of this association, and also the high class of papers presented, I certainly consider it a great honor to receive this medal, and while I have a feeling that I am not worthy to receive it, I gratefully accept the decision of the committee.

I shall hereafter enter the date February 12 in my personal calendar as a red-letter day, celebrating not only the birthday of Abraham Lincoln, but also the day on which I received the Dexter Brackett Memorial Medal. [*Applause.*]

An Address by Lieut.-Col. George A. Johnson.

The President. We have with us to-day an honored member of this Association who told me a little while ago that he belonged to about all the societies there were a-going, and that he placed the New England Water Works Association among the first. [*Applause.*] He also laughingly suggested that he was thinking of making an application to the Colonial Dames for admission to their society, and I told him I hadn't any doubt but that he would at once be accepted on his uniform and his good looks. [*Laughter.*] It now gives me great pleasure to call on Colonel Johnson. [*Applause.*]

Lieut.-Col. George A. Johnson. *Mr. President and Members of the New England Water Works Association,* — This is quite unexpected. [*Laughter.*] When I was accosted by your worthy President, — our worthy President, I should say, — he asked me if I would say a few words to you to-day about the work of the Construction Division of the Army. I think you will judge from the state of my voice that I have been saying quite a few already.

Lots of us were either too fat to fight or too old — as the recipient of the medal suggested — to do our bit at the front, but it was our good fortune to be placed at least in the home forces to carry on the work here at home. Active warfare is for youth; it is the supreme moment for them. But without the second line and the third line and still other lines back of them until they finally reach back to us here, youth could not go forward and experience that supreme moment.

The Construction Division of the Army is an organization of which little has been said. Everybody in it, from the chief down, has been too busy to make public speeches or to write public stories. Shortly after the war broke out in April, 1917, there came the duty of providing quarters for the new army, not only places for them to sleep in, but complete facilities. Then in charge of such construction work was the Construction and Repair Division of the Quartermaster-General's office. It was hoped at the time that that division would expand so as to be able to take this tremendous load, but it did not advance fast

enough. With the aid of civilian engineers and civilian advisers, — among the most worthy were those coming from this territory, — there was formed the Construction Division of the Army reporting direct to the Chief of Staff, the only division in the War Department reporting direct to the Chief of Staff.

We wish to make it very plain that we are not connected directly with the Quartermaster-General's office. We wish to have it understood distinctly among you gentlemen that the Construction Division of the Army is the civilian engineer division of the War Department. That seems to have been somewhat misunderstood. It also seems to be the general conception that we are a part of the Engineer Corps of the army, which we are not. We have a distinct work to perform, a work which no one has ever done but the civilian engineers, whether in uniform or not.

When America entered the war one of her problems was the housing of the new army. For the expeditious creation of complete cities, each housing an average of forty thousand men, the engineer, the architect, the city planner, the constructor, and the labor agent were called into the service as the Construction Division of the army. Instead of attempting to set up a number of organizations, it went to the civil life from which it sprang, and called upon the existing contracting organizations, engineers, and producers of materials, to aid in the accomplishment of its task.

The magnitude of the undertaking cannot be over-emphasized. In a little over three months the Cantonment Division was expected to have suitable quarters ready for the training of over 1 000 000 men.

The work of the Construction Division, in magnitude, speed of accomplishment, number of workmen employed, and materials involved, dwarfs any other construction or engineering project the world has ever known. The Panama Canal required ten years to construct, and cost approximately $375 000 000, whereas the work of the Construction Division for one year and a half exceeded three times this amount. While the work was being done, there was a shortage of labor and materials and congestion of transportation facilities unequaled in the world's history.

At one time 200 000 men were employed in the field alone.

The work included 535 operations at 442 different and widely separated locations.

The housing accommodations comprise about 40 large camps and several hundred minor projects, providing accommodations for more than 2 259 000 men. In the case of camps, a complete city was built, including roads, walks, electric lights, water supply, sewers, sleeping quarters, mess halls, lavatories, theaters, post-offices, store buildings, telephone and telegraph offices, power houses, laundries, storage buildings, hospitals, stables, garages, etc.

At army bases, interior posts and expeditionary depots, warehouses, terminals, piers, wharves, and docks have been constructed on an hitherto unequaled scale. The areas total 27 502 300 sq. ft. of warehouses and pier sheds and 2 176 000 sq. ft. of open sheds, giving a grand total of substantially 30 000 000 sq. ft., or 690 acres, of storage space. This equals a building 70 ft. wide and 80 miles long, or about equal in length to the distance from New York to Philadelphia. Most of the warehouses are of reinforced concrete. These figures do not include miscellaneous warehouses, magazines, or those at camps, or used exclusively by the Ordnance Department. Adjacent to the terminal piers and docks there are 39 000 lin. ft. of wharves, equivalent to 7.4 miles, for loading ships. This wharfage provides channels with a depth of 35 ft. at low tide, and is sufficient to berth 65 ships at one time on the basis of 600 ft. in length of wharf per ship. There have been built 1 644 miles of railroads exclusive of local trestles, etc., and 1 061 miles of roads of which a large percentage are concrete.

The Hospital Section has built or reconstructed buildings to accommodate 121 000 patients' beds, and in addition has provided quarters for about 12 000 nurses, 24 000 enlisted personnel, and 4 000 doctors.

For the Ordnance Department, alone, there have been built more than 7 933 000 sq. ft., or 181 acres, of industrial and storage buildings, about 7 000 lin. ft. of docks, and about 3 250 000 sq. ft. of magazines. The work for the Ordnance Department and the Chemical Warfare Service has aggregated at cost of about $150 000 000, of which the following is a brief description:

Six artillery proving grounds, of which the largest, at Aberdeen, Md., contains about 38 000 acres and has cost about $15 000 000.

Seven ammunition storage depots, of which the largest one, at Raritan, N. J., contains over 150 fireproof magazines, has a storage capacity sufficient for nearly $400 000 worth of explosives, and cost about $12 000 000. Most of these depots are provided with extensive dock facilities and from twenty to thirty miles of railroad sidetracks.

Various fireproof building construction of steel, brick, reinforced concrete, and hollow tile, together with the installation of miscellaneous machinery, etc., at nine of the permanent government arsenals, which are scattered from New England and the Atlantic Coast to California and Texas. At Watervliet it included a steel and concrete machine shop about 250 ft. by 600 ft., and other buildings of like character, which added about four thousand to the manufacturing force at that point.

Nine plants for assembling ammunition, etc. Several of these installations cover three or four square miles, contain three to five hundred separate buildings in the one plant and thirty or forty miles of side tracks, besides power station, machinery, and equipment of all kinds.

Twenty chemical manufacturing plants, with their buildings, facilities and equipment. These plants cost from $1 000 000 to $13 000 000 each, and in most cases included housing facilities for the operating forces, as the plants were necessarily isolated.

The Edgewood Arsenal, at Edgewood, Md., includes an extensive plant for producing chlorine and other gases, an extensive gas shell filling plant, fireproof barracks, two hospitals, 600-ft. dam and reservoirs, and a 20 000 kw. power station, and cost about $25 000 000.

The work of the Construction Division, summed up briefly, has covered such diversified projects as camps, cantonments, wharves, docks, forts, arsenals, great port terminals, reserve storage warehouses, hospitals, of all sizes and descriptions, aviation fields, proving grounds, embarkation camps, engineer camps, gunnery schools, housing, lighters, power plants, factories, additions to manufacturing plants, munitions plants, and special new plants, — for the production of nitrates, phosphorous, T.N.T. and other acids, gas, and explosives.

On top of the construction work there comes still another factor,

and that is the operation of these institutions. In the Construction Division there is the Maintenance and Repair Division. I have always thought that the nomenclature was somewhat unfortunate. We in civil engineering life are more fond of operation and maintenance. This division to-day has complete charge of the operation and maintenance of establishments, consisting of the major camps and cantonments, some 50 odd hospitals, 25 terminals and storage depots, together with the 66 border stations and the regular army posts. We have a force of 501 commissioned officers and 16 559 enlisted men. Those are spread over the establishments. All of the work of those establishments is directed from the Washington office. Much of the time the Washington office is directed from the field, for we don't let the tail wag the dog. We in Washington realize that our duty is to endeavor to work out the problems as they come to us from our men in the field, to judge them, to act dispassionately upon their reports to us, and to see that the men in the field are supplied with money and with men and with facilities to do their work. We know that the man in the field has a much harder job than we have. He is dependent to a large extent on us, but more largely on his own resourcefulness; and the way he has come through in this job is marvelous.

In the field there is a utilities officer. Under him are chiefs of sections. Each utilities officer functions just the same as a city manager functions in civil life. We are the head office of the city managers. The duty of the utility officer in each one of these establishments is to maintain the roads and keep them in good condition; and when we realize the intensive use to which they have been put in this last year and a half you can imagine what a gigantic task it has been. The buildings, put up without painting, have fallen into bad repair. Those have to be kept up. Windows have to be kept tight; the roofs have to be kept tight; the electric-lighting systems, put down hurriedly and without mature consideration, have to be revamped; and they have to function with high efficiency, or else the man gets " bawled out " by the Washington office, where we have expert electrical engineers to check up the work in the field.

In each camp there is, of course, a water department. In some

places the water is purchased; in others it is produced independently. The water has to be filtered in some cases, and experts in that line are on the job. The sewerage systems, laid out hurriedly, as they had to be, have in all cases proved adequate, and that is remarkable when it is considered how swiftly they were put down. The disposal of the sewage has to be taken care of the same as in civil life, in order that there may be no nuisance created through the discharge of the effluent into streams. Heating plants have to be operated with high efficiency, in order that the men may be kept warm and comfortable, especially in the hospitals. Refrigeration plants have to be run in order to keep perishable foods and to manufacture ice for issue. The whole problem is one of tremendous city management, because even though in sum totals they may only run into a couple of million men, the communities themselves are so widely scattered in so many localities, with so many different factors governing.

Then as to costs. We have made a complete and careful analysis of the costs of operation of all of these utilities, and we are prepared to state and prove by actual figures that the electric-lighting systems, the roads, the buildings, the heating plants, the sewerage systems, all of those things that make up a modern city, have been operated and maintained at a cost not higher and even in some cases lower than those in the best managed commercial projects or best managed state or municipal institutions. That is a strong statement, but we can substantiate it by figures and facts. And we take pride in it in giving an account of our stewardship. It has been a big job, and we are all proud of it.

There were a great many men — I think you might say 101 per cent. of us, — who wanted to go abroad, but our duty was here; we could do better work here than we could there. There is a glamour, of course, to be spread over foreign service. There is also a glamour to be spread over self-sacrifice. We have in our force a great many young men who have been thrust back because of some physical disability, and there are others who were judged to be too valuable to be sent. And when the final summing up comes of " who is who " in the war there must be a tremendous amount of credit given to those who have so ably served in the Construction Division of the Army, who are entitled to a high

place in history and who, I think, will never be forgotten when the story is fully told. [*Loud applause.*]

THE PRESIDENT. Mr. Fales, the chairman of the Sanitary Section of the Boston Society of Civil Engineers, has an announcement to make.

MR. ALMON L. FALES. At a meeting of the Sanitary Section of the Boston Society of Civil Engineers we are going to have the pleasure of hearing Colonel Johnson tell us of the operation and maintenance of the utilities at the army camps and cantonments. I am sure from what you have heard him say this afternoon that you will all be interested to hear in detail of his work. In the name of the Sanitary Section I extend to the members of the New England Water Works Association a cordial invitation to come to that meeting, which will be held at the Engineers' Club at 7.45 P.M., on Wednesady, March 5. Preceding this meeting we are to give a dinner to Colonel Johnson, and we shall also be very glad to have you join with us in thus honoring him. The dinner will be at 6.30, and I will ask any of you who wish to join with us to send a card to that effect to our clerk, Mr. Henry A. Varney, 715 Tremont Temple, Boston.

THE PRESIDENT. In behalf of the Association I thank you for the invitation, and I will see that our members are notified in due time.

I have been requested to call attention to House Bill No. 760, now before the legislature, on which there is to be a hearing next Monday before the Joint Judiciary Committee. This is a bill to make water bills a lien on property. It has been up several times before, but I do not think it has ever got out of the committee.

Mr. Metcalf has written me a letter, but as I see he is present I will ask him to state to you personally what he has stated in the letter to me.

MR. LEONARD METCALF. *Mr. President and Gentlemen,* — I was anxious to find out for some water-works men whether any of you had information or experience upon agreements between water works and municipalities, looking to the taking over of the works by the municipality on a basis under which it was possible for the municipality to make payments of given sums from time to time, and under which any surplus earnings above a certain amount,

specified in the agreement, were to be applied to the purchase of the works.

It has been suggested that some such method as this might be used, as means of settling questions which were vexed, between the water company and the municipality, particularly if there should be represented on the directorate of the water company the city authorities. One of my clients has been considering the making of such an agreement as that, based upon allowance of a certain rate of return upon the outstanding stock of the company, as well as the interest upon the bonds, — an agreement being arrived at with the city in regard to the relation between the outstanding securities and the fair value of the property.

It seemed to me that this subject was one which would interest water-works men, and that it had in it a germ of thought that might be useful to water works, and so I am anxious to find out whether any of our members have had any experience of this sort.

The plan is somewhat analogous to that which was developed in Chicago in settling the electric railway situation, and I think on the whole has worked out fairly well there. It is my impression that the city of Louisville, Kentucky, took over its water works on some such basis. The details I have not yet been able to find out about, though I expect to have information in the course of a few days. In the case of Burlington, Ia., I find that there was another example of an agreement under the terms of which the city has already acquired a very substantial interest in the works, which are still being operated by the water company; and the city is looking forward to finally acquiring the works under terms which are acceptable to the water company, and which the city officials consider distinctly advantageous to the city.

I should be very grateful, therefore, if any of you know of any such examples, if you will let me know, or let one of the members of the Executive Committee know, of them, so that they may be rounded up for presentation at a later date at one of our meetings.

The President. Is there any one present who can give us any information on the subject now? It appears to me to be a very interesting matter.

Mr. Samuel H. MacKenzie. The town of Southington took the works from the Southington Water Company, and they acquired them under an agreement that they should pay the cost of the works plus six per cent. less the dividends. It is a little more complicated than it seems from that statement, perhaps, but that is the way the works were acquired.

The President. It seems to me this is a very interesting subject, and I trust that Mr. Metcalf, after he gets the information together, will at some date present it in such form that it can go into our records for reference.

The President then called upon Mr. Robert E. Horton, hydraulic engineer, Albany, N. Y., who read a paper entitled, "Measurement of Rainfall." The subject was discussed by Mr. Desmond FitzGerald, Mr. R. C. P. Coggeshall, Mr. Charles W. Sherman, and Mr. X. H. Goodnough.

Mr. L. M. Hastings, city engineer, Cambridge, Mass., presented a paper entitled, "Some Practical Uses of Rainfall Records."

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association was held at headquarters, Tremont Temple, Boston, Mass., at 11 o'clock A.M., December 11, 1918.

Present: President Carleton E. Davis, Samuel E. Killam, Henry V. Macksey, Thomas McKenzie, Frank J. Gifford, Lewis M. Bancroft, and Willard Kent.

The following applications were received and recommended for membership, namely, John W. Moran, superintendent water works, Fall River, Mass.; Timothy W. Good, superintendent water works, Cambridge, Mass.; Willard A. Keene, manager Turtle Creek office, Pennsylvania Water Co., Turtle Creek, Pa.; Launcelot P. Marshall, chief engineer, Rangoon Municipality, Rangoon, Burma, India, and V. T. Givotovsky, post-graduate student, Mass. Inst. of Technology, Allston, Mass.

The death of James Burnie, vice-president of the Association in 1901, 1902, 1905, and 1915, was announced as occurring on the 27th of last month, and the preparing of an obituary notice was referred to the Editor.

Adjourned.

Attest: WILLARD KENT, *Secretary*.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Wednesday, January 8, 1919.

Present: President Carleton E. Davis and members Samuel E. Killam, Henry V. Macksey, Percy R. Saunders, Lewis M. Bancroft, and Willard Kent.

The application of Schumaker & Santry for associate membership was presented and unanimously recommended therefor. The report of the committee on Award of the Dexter Brackett Memorial Medal for the year 1917 was received, and it was unanimously

voted, that the award of the Dexter Brackett Memorial Medal for the year 1917 be, and hereby is, made to Mr. Albert L. Sawyer, water registrar of Haverhill, Mass., for his paper entitled, "Some Advantages of a Classified Cash Book."

Voted, that Messrs. William T. Barnes, William F. Sullivan, and George W. Batchelder be and hereby are constituted a committee to recommend the award of the Dexter Brackett Memorial Medal for the year 1918.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association held at headquarters, Tremont Temple, Boston, Mass., February 12, 1919, at eleven o'clock A.M.

Present: President Samuel E. Killam and members Henry V. Macksey, Charles W. Sherman, James H. Mendell, Frank J. Gifford, Patrick Gear, Willard Kent, and Lewis M. Bancroft.

Voted, that the President be and hereby is authorized to appoint a committee with full power to make arrangements for the June meeting of the Association.

Voted, that Messrs. A. R. Hathaway and Patrick Gear be a committee to investigate and report with reference to the place of holding the next annual convention.

The question of printing the membership list for the current year is discussed and referred to the President for such action as he may deem best.

Voted, that the President be and hereby is authorized to make arrangements to allow the associate members to conduct a portion of some meeting of the Association after the dispatch of the routine business.

The Secretary presents certificate of renewal of the Treasurer's bond for two thousand dollars by the Massachusetts Bonding Company, which is by unanimous vote approved.

The following applications, properly endorsed, are received and the several applicants are by unanimous vote recommended for membership of the Association, viz., A. R. G. Booth, Lowell,

Mass., assistant chemist, Mass. State Department of Health; Thomas J. Carmody, Holyoke, Mass., water commissioner; George M. Graffam, Portland, Me., auditor for Portland Water District and Bangor Water Works; W. W. Nye, Fairfield, Me., real estate; A. B. Thompson, Waterville, Me., assistant superintendent Kennebec Water District.

Adjourned.

Attest: WILLARD KENT, *Secretary*.

ROLAND DWIGHT BARNES.

WORD is just received of the death of Roland Dwight Barnes, which occurred at his home in Bristol, Conn., in August, 1918, after an illness of two years, although he was able to attend to business till within about two weeks of the end.

Mr. Barnes was born December 23, 1855, and received his education in the schools of Forestville and Bristol, Hartford High School and New Britain Normal School. After teaching school a short time he took up the practice of his profession, that of civil engineer, with the Bristol Water Company, building their first reservoir and continued as their engineer till 1887.

Mr. Barnes then became associated with the Pittsburg Water Works and Guarantee Company of Pittsburg, Pa., building water works in various parts of the country, and later transferred his office to Boston and was connected with development of water power on the Androscoggin River at Rumford Falls, Me. He then spent about fifteen years on construction and maintenance of sewers in Malden, Mass., from which he returned to Bristol and supervised house and factory building for the Bristol Brass Company, and was employed by the Wallace Barnes Company at the time of his death.

He is survived by his wife, daughter, and a brother.

Mr. Barnes was a member of the New England Water Works Association from 1899, and was associated with the Methodist Church and was a member of the board of trustees, also with the Independent Order of Odd Fellows and Knights of Pythias.

He was one of Bristol's best citizens, of high standing in his profession and upright and honorable in all his dealings.

The New England Water Works Association, in common with his town and state, has lost an honored member.

CHARLES HENRY BALDWIN.

The passing of Charles H. Baldwin, which occurred January 23, 1919, takes away one who had made a remarkable record in several fields of activity. Mr. Baldwin was born January 13, 1852; was "turn-on" and "turn-off" clerk of the Boston Water Department from 1874 to 1883. Then followed two years with

the Equitable Meter Co., which he left to become New England manager of the National Meter Co., a position he held with the greatest credit till July 1, 1913, when he was made president of the Franklin Savings Bank of Boston.

In this work he was eminently successful, and closed his career having gained and retained the highest esteem, respect, and confi-

dence of a legion of acquaintances. Mr. Baldwin was an active member of the New England Water Works Association from 1887 but had been an associate member previously.

For many years he was active and took a deep interest in its affairs.

He first appeared before the Association at the Worcester Convention of 1883, to discuss " The Causes and Prevention of the Waste of Water," and was present at nearly all gatherings and took an active part in the programs. At the joint convention of the American and New England associations, held at Young's Hotel in April, 1885, he did very effective committee work.

Mr. Baldwin's circle of interests included membership in Society of Colonial Wars, treasurer of Home for Aged Men, director of the Washingtonian House, member of Trinity Church and deeply interested in the affairs of the diocese.

He is survived by his wife.

Although his many business demands prevented active participation in water-works affairs during the last few years, the Association feels a distinct loss in the passing of one who had been a strong factor in making the New England Water Works Association the powerful organization it is to-day.

IN MEMORIAM

Lettice Roderick Washburn.

Born March 14, 1848. Died December 27, 1918.

Member New Bedford Water Board from June 23, 1904, to the date of his death. Joined this Association March 11, 1908.

BOOK REVIEWS.

"Conveyance and Distribution of Water for Water Supply." By Edward Wegmann, C. E.

(*Reviewed by* Fred O. Stevens.)

In the seven hundred pages of his "Conveyance and Distribution of Water for Water Supply," Mr. Wegmann has assembled a vast amount of water-works data from the leading textbooks, journals of engineering societies, technical magazines, and trade catalogues, of this and other countries.

Part I gives, in a concise manner, the deduction and application of such formulas as are necessary for the solution of the ordinary problems relating to the flow of water in pipes and channels, with tables of coefficients to be used with them. The data on loss of head due to curves and valves are much more comprehensive than that found in textbooks, and the coefficients given are the result of a large number of experiments.

Part II, treating of design and construction, takes up briefly but clearly the analysis of stresses in cast-iron, wood, and riveted-steel pipes, standpipes and trestle towers, together with enough of the mechanics of materials to enable the engineer-superintendent to solve intelligently such problems of design as are apt to occur in connection with his everyday work.

Methods of manufacture of the various kinds of pipe are fully described, as are also construction methods for a number of water-works structures; but the greater part of this section is taken up by descriptions of notable existing works in this country and abroad, some one hundred pages being given to descriptive matter on intakes and aqueducts, an amount of space which seems somewhat out of proportion to that allowed some other subjects, in a volume which is described on its title page as "a practical treatise for water-works engineers and superintendents."

The subject matter of Part III, on maintenance and operation should, prove of great interest and value to beginners in water-works management, to commissioners in small towns, and others who are called upon to administer the affairs of water systems without having had practical water-works experience.

The author describes the latest approved tools and appliances, fixtures and fittings, and water-measuring and recording devices, in great detail, with illustrations from trade catalogues of each article described. An example of the detailed description of tools and processes in this section is afforded by the following paragraph:

"After the lead has been poured, the surplus of lead is cut off with the lead-cutting chisel, and the joint is calked by means of the calking irons and a hammer weighing about $3\frac{1}{2}$ pounds. The thickness of the calking irons at the point varies from $\frac{1}{8}$ to $\frac{7}{8}$ in."

The paragraph is illustrated by cuts showing a full set of calking irons and hammers.

The chapter on water meters is in itself a treatise on all known appliances for the measurement of the flow of water through pipes. Not only every type, but practically every make of meter from the smallest disk to the largest Venturi, including the recording devices used with Pitot tubes, is described by means of text, cuts, and diagrams. It is to be regretted that the author could not have devoted a few pages to the subject of meter maintenance and repairs, which, although of great importance to superintendents, has hardly been touched upon in water-works literature.

The work as a whole is essentially a compilation, and as such will be of great value to the busy water-works manager who cannot possibly have access to the many sources of information of which the author has availed himself. Its greatest value to the engineer and to the superintendent of mature experience who desires to broaden his knowledge gained experimentally, lies in its abundance of references, which, without exaggeration, may be said to cover practically the entire field of literature on water distribution.

"Water Rights Determination." By Jay M. Whitham. — New York, John Wiley & Sons, 1918.

(*Reviewed by* Charles W. Sherman.)

This book is the outcome of Mr. Whitham's long experience in water-power rights cases, and represents the fruits of a very painstaking investigation in old books and pamphlets, reports of law cases, etc. In his preface, the author says:

"This book is intended to assist an owner of an indefinite water right in determining:

1. The meaning of his right as expressed in horse-powers; and
2. The number of cubic feet of water per second to which he is entitled."

The first part of the book contains data from many sources relating to the power required to operate a run of stones, a saw mill, a cotton mill, etc., as indicated by the various authorities which the author has been able to find.

The second part is devoted to a discussion of the quantities of water discharged through bulkhead gates and through various types of water wheels and turbines, more especially the older and now nearly obsolete types of wheel used in most of the early mills, to which such indefinite grants of water apply.

The book is destined to be extremely useful in every case of an indefinite water-power right.

Annual Convention to be held in Albany, N. Y.,
September 30, October 1, 2 and 3, 1919.

Volume 33. JUNE, 1919. $3.00 a Year.
Number 2. $1.00 a Number.

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ISSUED QUARTERLY

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Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

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OF THE

New England Water Works Association.

1919.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXXIII. June, 1919. No. 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

BREAK IN NO. 2 HYDRAULIC TURBINE AT WACHUSETT POWER STATION, CLINTON, MASS.

BY WILLIAM E. FOSS, CHIEF ENGINEER, METROPOLITAN WATER WORKS.

[*Read March 12, 1919.*]

The Wachusett Power Station of the Metropolitan Water Works is situated just below the Wachusett Dam in Clinton.

The building is of granite masonry, 100 ft. in length by 70 ft. in width, and the easterly portion is used for the Wachusett Department offices. The superintendent's office is on the second floor, and the civil engineering office is on the third floor, with a loft above it.

The hydro-electric machinery is on the first floor, which is about 92 ft. below high water in the Wachusett Reservoir.

The plant includes four 1 000-kw., 13 800-volt alternating-current generators, directly connected with horizontal-shaft hydraulic turbines, which operate at a speed of 400 revolutions per minute, and two 60-kw., 125-volt direct-current exciter generators also operated by hydraulic turbines. Each of the main turbines is provided with a type Q Lombard governor, arranged for automatic or hand operation as desired.

The water supply for each unit enters the gate chamber through ports in the upstream face of the dam, and after passing the screens enters a vertical circular well 7 ft. in diameter through two openings, each 6 ft. high and 2½ ft. wide, which are provided with sluice gates arranged for operation by hand or by electric motor, as desired.

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VIEW FROM SUPERINTENDENT'S OFFICE.

SUPERINTENDENT'S OFFICE.

The escaping water knocked the helper down and swept him along the floor between No. 1 and No. 2 generators, by the front door, to a radiator near the westerly end of the station, where he was able to regain his footing and left the building through a window. The water was then level with the window sill and about two feet deep over the floor.

Meantime the operator returned to the switchboard and opened all of the electric switches and left the building through the rear door.

The two men then went up to the gate chamber and with the assistance of some other employees closed the sluice gates and stopped the flow of water about thirty-five minutes after the break occurred.

The water flowed out of the opening in the scroll case under a head of 70 ft., probably in a nearly solid stream, which struck the door leading from the superintendent's office to a small balcony in the power station, for it is difficult otherwise to account for the effect of the water, which upset a heavy iron safe about 7 ft. high by 4 ft. wide by 2½ ft. deep, and completely wrecked everything else in the office.

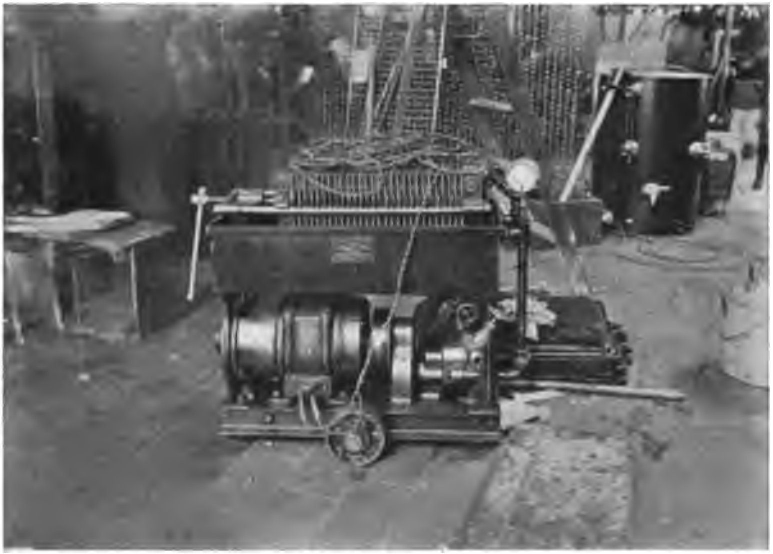
One of the large front windows was broken at a height of about 25 ft. above the floor, and some of the water shot up about 35 ft. above the floor to the top of the room, broke an interior window, entered the loft, and dripped down through the ceiling into the civil engineers' office, but caused little damage.

The water flooded the power station floor to a depth of about 4 ft., broke open the front and end doors and flowed out over the lawn, driveway, and walks into the river. It also broke down a wooden partition at the air shaft and flowed through the iron grating in the floor into the Wachusett Aqueduct.

The heating plant is in the southeast corner of the basement, and there is an opening in the floor above it about 12 ft. long and 6 ft. wide. Water dropped through this opening on to the heater and tore off all of the magnesia insulation and put out the fire. Water also flowed down the stairs at two points into the basement and thence into the river through drain pipes, which appear to have been of sufficient capacity to prevent its filling the basement, as the transformers connected with the Clinton Sewer-

age Pumping Station line, which are located on a shelf under the power station floor, were not disturbed.

The station lighting and power service transformers and many of the instrument transformers were located back of the switchboard near the floor, and the water rose above the top of the cases and displaced the oil, causing short circuits which grounded all



Oil Dryer and Filter.

the lines and caused some minor burn-outs and breakage of insulators on the oil switches.

Above the flood line everything was wet, apparently by spray from the main stream. The rotors of generators Nos. 1 and 4 continued to revolve for a time, partly submerged in the water, and the insulation of the field and armature coils was cut and scraped in places. The coils on generator No. 2 were also cut and scraped but no injury of this nature was found on No. 3 generator. Aside from this mechanical injury all of the damage to the electrical apparatus is due to moisture.

As soon as the water had drained out of the building the heating plant, which was in working condition, was put into service and

the oil and water were mopped from the floor, walls, and apparatus.

After operating No. 1 exciter generator without load for a time, to dry it out by windage, it was put into service to furnish lights, and generators Nos. 1, 3, and 4 were then put into shape and operated without load during the night, to dry them out by windage.

On Tuesday, arrangements were made with the Standardizing and Testing Department of the Edison Electric Illuminating Company of Boston for drying out and testing the electrical apparatus. The necessary equipment for this work was shipped from Boston by auto truck late in the afternoon, and the work was started the following morning.

A connection was first made with the New England Power Company's line by using portable transformers, oil switch, circuit breaker, and watt-hour meter from the Edison laboratory, so that alternating current would be available for drying and testing the electrical apparatus and for operating the Clinton Sewerage Pumping Station, as the old steam plant at the pumping station, which had been kept in reserve for emergency use, was not operating satisfactorily.

This work was completed Wednesday night, and meantime canvas had been obtained for covering two of the generators which were being dried out by operating them with the armatures short-circuited and a low field excitation, and for the construction of ovens which were heated by means of electricity and used for drying out transformers and other apparatus.

Although openings were provided for drainage of the electric ducts, when they were built into the concrete floor, some of them had become clogged and there was standing water in some of the ducts which made it necessary to disconnect and withdraw the wires in order to dry them out. After the water had been removed from the ducts with swabs, they were dried out by blowing warm air through them. The wires which had also been dried were then replaced and tested.

On February 25, unit No. 3, which had then been dried out and satisfactorily tested, was put into service again. This unit was not in operation on the 17th when the accident occurred, and was uninjured except by moisture.

Arrangements having been made with the Lundin Electric and Machine Company of Boston, for repairing the commutator on exciter No. 2 and the insulation on the field and armature coils of the main generators, this work was begun on February 24 and was completed March 4. On the same day, unit No. 1, which had been dried out and satisfactorily tested, was put into service again, and three days later unit No. 4 was put into service.

Generator No. 2, which could not be operated, was dried with air from the blower and by circulating current from unit No. 1 through the coils while stationary. Satisfactory insulation tests were obtained on this generator on March 10, but it cannot be put into service until the work of repairing the No. 2 turbine, which will probably require at least two months, is completed.

Special electrical equipment used in connection with the repair work includes an electrically operated oil pump and filter for removing water from transformer oil, an electrically operated blower and grids for supplying air for drying purposes, transformers, resistances, and instruments for high-potential testing.

DISCUSSION.

MR. CARLETON E. DAVIS. Are you prepared, Mr. Foss, to say what was the cause of the accident?

MR. FOSS. All I know is that it apparently followed the pulling of the clutch which releases the wicket gates from the governor control and puts them under hand control. I am inclined to believe that in connection with that the gates closed suddenly, and caused sufficient water ram to break the casting.

MR. F. H. HAYES. How thick was the casting on the top?

MR. FOSS. The casting varies from 48 in. in diameter down to about 24 in., and the thickness decreases with the diameter. At about the center of the break the thickness was $\frac{15}{16}$ of an inch.

MR. HAYES. Did it vary as it went through the bottom of the cylinders or the sides? Was it thicker on top than on the sides?

MR. FOSS. The casting increases in thickness at the hub where there are guide vanes inside. There appeared to have been an

internal strain in the iron at one of the vanes where the thick section of metal was located. Aside from that the iron looked very good. I am having some test bars made, to determine the quality of the iron.

MR. ROBERT S. WESTON. How far away were the pieces thrown?

MR. FOSS. One piece was found between generators 1 and 2, about 10 or 15 ft. from the break; and a smaller piece was found out in front of the power station. Apparently the water had drifted them around so that they were not found where they landed.

MR. HAYES. Was there any indication of erosion on the inside of the case?

MR. FOSS. No, none whatever. The original paint is still in good condition.

MR. RICHARD A. HALE. I should like to ask if there is any apprehension in case of the other turbine, in the case of a sudden closing, that a similar accident might happen, and whether any strengthening might be applied.

MR. FOSS. Yes; we are considering that question. Apparently, No. 2 turbine was the same as the others. I might say, however, that from examination of all four, No. 2 appears to be the roughest casting, and perhaps the poorest one. But aside from that they are identical castings, I suppose. And the liability of breaking one of the others by a sudden closing of the gate exists. We are considering making some experiment to determine how many seconds it takes to close the gates with the present setting of the governors, and the possibility of putting a dash pot of some kind on the gate mechanism, so that even when it is thrown off from the governor it will take several seconds to close.

MR. PERCY R. SANDERS. Is the water that operates these generators a part of the supply of the Metropolitan system or waste water?

MR. FOSS. It is a part of the supply.

MR. ——— (Reporter). I should like to ask what the total damage is estimated at.

MR. FOSS. I think that our expenses to date do not exceed $4 000, and we have yet to repair the broken turbine, which will

be the largest single item of expense. If the apparatus stands up as we expect it will after giving it a thorough test, — I do not see why the expense should exceed $9 000 or $10 000 for everything.

Note. Since the paper was presented charts from recording pressure gage installed on turbine No. 4 show a water ram of 5 to 10 pounds in connection with operation under governor control and of 60 pounds when clutch is pulled with a wicket-gate opening of 63 per cent.

The total damage will be less than $8 000.

ENGINES FOR SMALL WATER WORKS.

BY HENRY A. SYMONDS, CIVIL ENGINEER, BOSTON, MASS.

[*Read December 12, 1918.*]

In the design of a plant for pumping the water for a small community, it is usually the case that per capita cost of operating and maintenance is greater than in the large city plants, and it is important that a careful study be made of the relative merits of the different forms of power available, their adaptability, first cost, and efficiency when operating to do the particular work desired.

The educating of the general public to the importance of good water supplies has in recent years brought about a great effort by the citizens themselves, assisted by the health boards and others having to do with the prosperity and health of the communities, to introduce public water systems in the smaller towns.

It is usually the case that strict economy must be practiced in the introduction of these works, and studies relative to first cost have usually been made to bring the cost of the work within the ability of the communities to pay. Not so much attention, however, has been paid to the question of relative efficiency and daily cost of operation, and it frequently occurs that plants are in operation which the citizens of the town, and even the water-works officials themselves, believe to be highly economical, that are the reverse. The difference in cost of operation may be so great as to make it good business to pay a much higher price for an economical unit.

The early use of power for pumping water in the small-town installations was largely by water power or steam, and it is possible that water power is coming back into use for pumping purposes, but probably through the medium of the hydro-electric plants, as it is not common to find good water privileges so located as to be directly available for pumping from the approved sources of water supply.

Steam Pumps.

The use of steam in small plants naturally followed its use in the larger places, and was about the only kind of power available which could be utilized at any and all points.

Steam has been used for many years very efficiently in many small plants, due to the development of the steam pump by expert engineers, and we have to-day numerous examples of small pumping plants of the Dean, Knowles, Blake, Worthington, and other types that have shown good reliability and wonderful endurance, having operated continuously for the entire service of the plant from twenty to thirty years with very little repairs, and are able at this time to continue for an indefinite period in the future.

The common form of the earlier pumps was of the reciprocating plunger or piston type, in which the steam piston was upon the same stem as the water pistons, and this is still the most common form of steam application to pumping.

Steam Turbines.

The development of the centrifugal pump which has now found so wide a field was closely identified with the bringing out of the steam turbine.

The centrifugal pump has been known for a great many years, but for a long time after it was invented the difficulty of getting suitable drive with sufficiently high speed retarded the development of successful operation of this type of pump. The real growth of this pump has occurred in the last ten years, during which time the use of the steam turbine and the electric motor with direct connection to the centrifugal pump have brought up the efficiency of the pump to a relatively high stage. At the present time the use of the steam turbine as applied to pumping water is largely in the large units, and the motor is generally adopted for driving the smaller plants.

The result of the use of steam is, on the whole, satisfactory, but for the small water plants is subject to the objections that the economical pumping machines with boilers are expensive and occupy much space, provision for large storage of coal and adequate

pumping-station buildings are required, all of which add to the first cost of the plant and are aggravated by the fact that licensed engineers are required to operate such a station.

The Ideal Engine.

To-day we consider the ideal small pumping engine that which is economical in first cost, is self contained, i.e., operates from a source of power which is part of the engine or at least located in the same station. It is desirable to have it occupy as small space as is practicable, be simple in operation and not require the services of licensed men, easily repaired, quickly started, using fuel which is readily available at all times, and be capable of producing power at a relatively low unit cost.

Electric Motor.

Many of the conditions of an ideal plant are met by the electric motor and the electrical installation has become more and more common. The advantages are: low first cost; requires little space; low cost of maintenance; no expert supervision; is especially well adapted to drive centrifugal pumps with direct connection, which saves friction loss of gears, and prevents noise; may have automatic control; may operate during periods of low load at central station, thereby getting lower rates; instant starting; as it has no reciprocating parts, can be left to operate without attendance better than any other form of drive. The use of electricity has two serious defects in the average municipal plant; namely, it is not self-contained, but depends upon a line of wires and a power plant, usually at a distance, for its operation. For this reason neither one nor two units in a pumping station operated from the same plant is satisfactory to the insurance authorities, as they rightly claim that an accident to the wire line or the power plant will put both units out of use as quickly as one and leave the town or city in an unprotected condition in case of fire.

There is no exact figure which can be given for the cost of operating by electricity, as the cost of the electricity itself varies very greatly according to the conditions of its generation. The cost

may run to three cents per kilowatt-hour, in a plant where electricity is generated by coal and where the plant is below the size which can be operated at the greatest efficiency or the cost of electricity may be a fraction of a cent per kilowatt-hour, where it is generated by surplus water-power which may be running to waste over the dam for a period of the day or night.

The advocates of the use of motors base their claims of low cost of operation from the fact that attendance may be a minimum and that this is really the large item in operating small water plants. The writer believes that this argument has considerable merit and that the improvement in efficiency brought about recently in the centrifugal pumps and the low cost of the pump and motor, with the advantages above referred to, makes this form of pumping plant a very close competitor and in some cases it will be found to actually be a better business proposition than the other types of pumps and engines in spite of the difference in efficiency. There are many places where electric motors are proper to install for municipal pumping, and the writer has recently overseen the installation of a plant where it is intended to be used as an emergency pumping unit during the renovating of the other pumps and in cases of breakdown or other emergencies. During the past summer it has done the entire pumping for the city.

The following data may be of interest for comparison relative to operation of this unit during July and August, 1918.

Actual test for months of July and August, 1918, of 100-h.p. Westinghouse motor driving Goulds two-stage centrifugal pump, rate 810 gal. per minute, against total head of 301 ft. (Extra charge is made for high price of coal.)

July —	Pumped	33 449 850 gal.
	Total hours	647½
	Kilowatt-hours	52 840
	Current cost per 1 000 gal.	2 8/10c.
	Total charge	$948.53
August —	Pumped	31 409 280 gal.
	Total hours	608
	Kilowatt hours	45 070
	Current cost per 1 000 gal.	2 8/10c.
	Total charge	$876.66

If general expense, interest, and all proper costs of operating are considered, the cost per 1 000 gal. water pumped is 7½ cents.

Gasoline Engine.

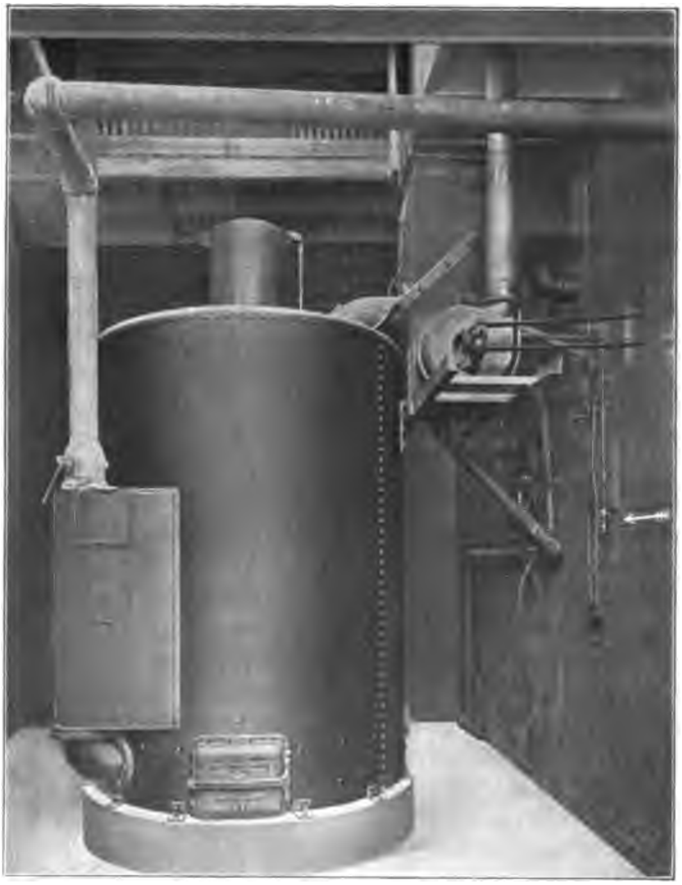
Another form of drive which has been used in some of the small pumping plants is the gasoline engine, and this form of power has practically all the advantages above mentioned except cost of operation, and in this it falls down badly, as it is operated upon a fuel of such high cost as to make the operation per horse-power hour too high for practical purposes in the ordinary municipal water works.

In plants, however, where an emergency unit is wanted and electricity is not available nor desirable for any reason, the gasoline engine may meet the requirements in a satisfactory manner. During the last season the writer had under his supervision the installation of a pumping plant for the Bumkin Island Naval Training Station. This was entirely for fire protection, and salt water only was to be pumped. Cost per horse-power hour was not a consideration for a plant of this kind, which was to be operated only in case of fire and for limbering-up purposes a few minutes a week. This unit consisted of a centrifugal pump driven by a direct connected Van Blerck vertical gasoline engine having a speed of approximately 1 500 r.p.m. The operation of this plant has been a success, and meets the needs of this particular case perfectly. It would be, however, entirely unsuited for a municipal pumping plant operating a number of hours per day continuously, as the fuel cost would be excessive, probably four or five times that of an economical unit.

Produces Gas.

The gas producer as a source of power corresponds to the boiler in a steam plant, and has a great many advantages, and when combined with a proper engine for utilizing the gas to the best advantage may be considered as having most of the requirements of the ideal plant. This form of power has been used for some time, and, so far as the writer has record, with good satisfaction in all

cases. Gas produced in this way may be used in various types of internal-combustion engines with slight modification. A plant of this kind can be installed at reasonable first cost, is self-contained



GAS PRODUCER (GALUSHA).

in so far as the power is generated directly next to the engine itself and operates at a remarkably low cost upon a relatively inexpensive form of coal. The plant takes up more room than some of the other types, and calls for a larger pumping-station space. One

of the latest developments of the gas producer is known as the "Galusha," and while the writer does not wish to appear as an advocate of any particular make of machinery, some of the ideas developed in this producer are of interest relative to small water plants. One of the advantages of this particular style of producer is that it requires but one tank and is very simple in its operation. It has been used to a certain extent for pumping purposes. The period between recharging is three hours. The coal consumption guaranteed is 1 lb. of coal per h.p.-hour. The coal used is usually of the less expensive grades, such as pea, buckwheat, etc., so that the operating cost is usually less than \$.005 per h.p.-hour. These producers are made in size from 18 to 350 h.p.

The efficiency of the Galusha gas producer runs from 62 per cent on very light load, to 86 per cent on very heavy load, and the producer will carry an overload of 25 per cent for three continuous hours.

The writer is indebted to Mr. George Hess, of the Nelson Blower and Furnace Company, for following report of test of Smith producer gas engine, and triplex power pump installed for the Lehigh Water Company, Easton, Pa.

Coal used, No. 1 Alden buckwheat.
Duration, 144 hrs.
Head, 208 ft.
Average speed, 46.8 r.p.m., or 3 029 g.p.m.
Speed of engine, 233.9 r.p.m.
Average temperature of starter, 75.2 degrees Fahr.
Efficiency of pump, 88 per cent.
Break h.p. of engine, 296.03.
Total weight of coal fed to producer, 36.152 lb.
Lbs. coal per break h.p.-hour, 93.32.
Lbs. coal per one million gallons water pumped, 1 381.2.
Calorific value of coal fired in B.t.u's per pound, 12 580.
B.t.u. per break h,p.-hour, 9 392.

The size of engine is above that properly considered in this paper, but may be of interest.

Gas producers are used in two smaller plants in the pumping station at Manchester, Mass. The first consists of two 65-h.p gas engines direct connected to two Goulds vertical triplex pumps,

each unit having capacity of 700 g.p.m., operating against a head of 280 ft. The second consists of two 50-h.p. engines direct connected to two Goulds double-acting triplex pumps, having capacity of 530 g.p.m. each against a head of 280 ft.

These units show an efficiency of 150 million foot-pounds per 100 lb. of fuel in daily operation.

The writer would suggest that this form of power be looked into by those contemplating the installation of small municipal plants.

Fuel-Oil Engines.

In the writer's experience, in nine cases out of ten, fuel-oil engines have proven an ideal installation for plants from 25 to 150 h.p., and for this reason it may be proper to give some extra details regarding this engine.

The term "fuel oil" is here used to mean any oil from the heavier crude petroleum up to kerosene. The fuel-oil engine as well as the gas and other forms of explosive engines have been the result of a long series of experiments and developments from the stage where gun powder was exploded in a cylinder to produce power to pump water, up to the present stage where it has met the greatest test of the ages in its use in naval vessels and submarines.

The perfection of this engine has brought the use of the submarine from a cruising radius of 500 miles up to that of 5 000.

Oil engines are now built up to 4 000 h.p.

The writer has at hand a brief history of the development of this engine which may be of some interest.

In 1860 the first step was made when Lenoir, a French engineer, succeeded in converting a steam engine into a gas engine and was able to develop some small engines of this type from one half to 10 h.p. These were of course of very low efficiency, but the principle of the internal-combustion engine had been given a positive start. A little later, another Frenchman, Beau de Rochas, improved the gas engine and brought into use the idea of compression, but was, however, unable to carry on to perfection his ideas, and N. A. Otto, a German, using the idea, developed the "silent motor" in 1877. The so-called "Otto cycle" contained

most of the main principles involved in the later development of internal-combustion engines.

In 1883 Stuart Akroyd, a Scotchman, utilized the Otto principle in an engine using petroleum oil. He was followed by Richard Hornsby, an Englishman, who perfected the engine and manufactured upon a large scale.

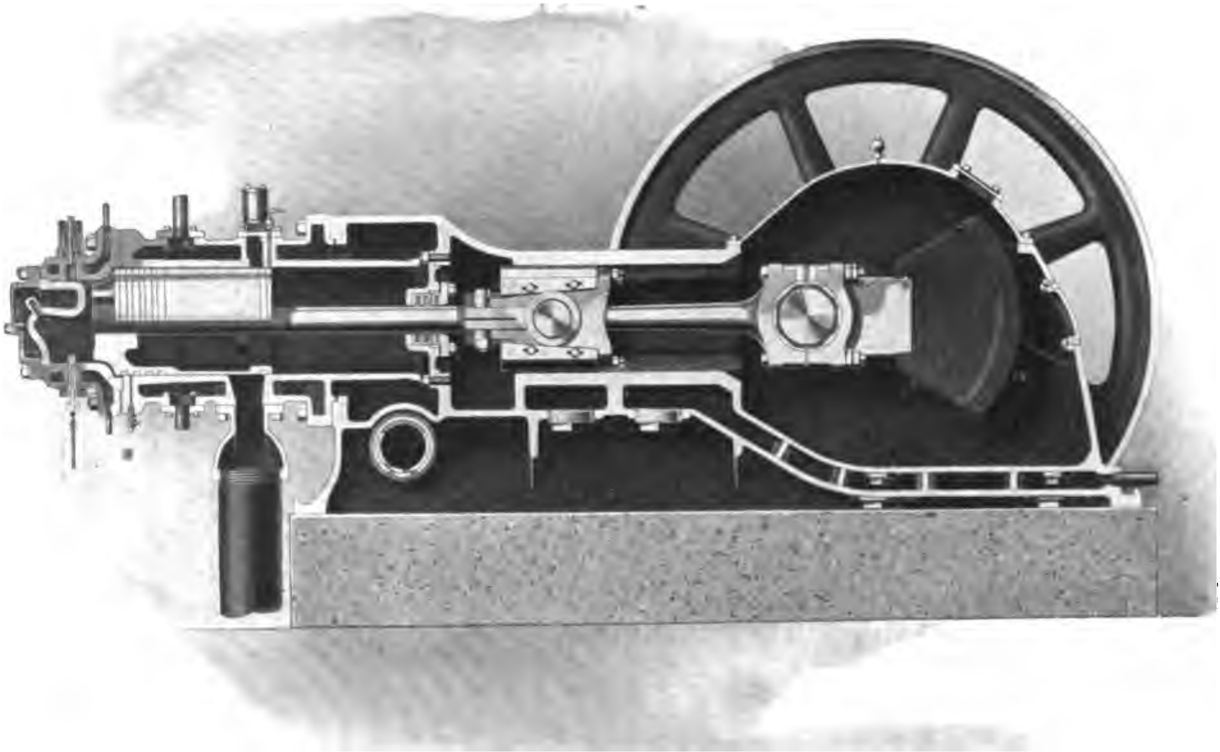
In 1892, Randolph Diesel conceived the idea of an engine running under high compression and able to use as fuel the heaviest crude petroleum or tar oils.

Fuel-oil engines are to-day known under two general heads as Diesel and Semi-Diesel, or surface ignition.

The idea conceived by Diesel is the bringing into compression a mixture of air and oil vapor to a point where heat is generated sufficient to ignite the combination. The compression reached varies from 500 to 1 100 lb. per square inch, but when the proper temperature occurs the gases burn rather than explode, and it is the claim of the producers of the Diesel type that this slower burning conserves the power of the gases and the energy realized is utilized almost entirely in pushing the piston through the length of its stroke. In order to permit of the great pressure produced by this process, the machine must be exceedingly heavy and the great amount of work which is required to perfect the Diesel engine makes them too expensive for the ordinary requirements of small water-supply plants.

The Semi-Diesel, or surface-ignition engine, on the other hand, gets its power by the explosion of a mixture of air and oil gas in the cylinder under the compression of around 200 to 300 lb. per square inch. While part of the energy is undoubtedly used in the shock against the metal of the plunger and cylinder, the resulting thrust produces motion of the piston, which is connected through the crosshead, or directly to a crank shaft which gives the motion to the driving pulley or gear.

The Semi-Diesel seems to meet all the ordinary requirements of the ideal engine described above, and while the first cost of this engine is considerably greater than that of the gasoline engine or the electric motor, the operating costs are so low that they outweigh in most cases the advantages of low first cost of the other machines.



Section of Fuel-Oil Engine (Bessemer).

For many years we have heard arguments by the advocates of the two- and four-cycle engine tending to prove that one or the other of these types was much superior and more economical in its operation than the other. In view of the claims and counter claims, the writer has felt somewhat disturbed that he has not been able after considerable investigation to determine positively which is the decidedly better machine, after having used first one machine and then another in all kinds of water-works installations, first that one was superior, then that the other showed more merit, and he must confess at this time that he does not know which is actually the more economical machine to operate.

The following table, while not a true comparison, as the two sets of machines are of different sizes, and operate under very different conditions, yet the quantities here may be of some value in showing actual costs of operating under normal conditions.

Actual unit costs of operating two-cycle and four-cycle engines, June 30, 1917, to June 30, 1918:

	Gal. Pumped per M.	Total Head.	Gal. Water Pumped.	Gal. Fuel Oil Used.	Gal. Oil per 1 000 Gal. Water.	H.P. Used.	Gal. Oil per H.P.-Hr.	Price per Gal. Oil.	Cost per H.P.-Hr.
2-cycle .	250	307	46 383 818	8 841	.19	24.2	.12	$0.084	$0.0101
4-cycle .	691	188	60 658 650	6 472	.107	46	.108	.091	.0098

The data in this table are taken from the logs of the pumping stations and are subject to more or less inaccuracies, but are probably very close to the true amounts, and in so far as this one comparison goes there is a striking similarity in the cost of operation. If the same price of oil is used in both cases the difference will be more in favor of the larger four-cycle engine, but on the other hand the larger machine has a slight advantage because of size.

To describe the action of the two-cycle engine briefly: After the explosion stroke is completed, the exhaust port is un-

covered by the return of the piston, and the ejection of the burnt gases takes place in connection with the injection of the new gases.

The four-cycle engine accomplishes the same purpose as the two-cycle, but does it in four strokes of the piston instead of two. There are several installations in New England where both the two- and four-cycle engines are used together, but the writer is not able to learn from the operators of these plants that an appreciable variation in the merits of one over the other is apparent.

The ignition is brought about in the Semi-Diesel engine by a hot cylinder head or tube which is first heated to the proper temperature by a blow torch and is afterwards kept at a red heat by the explosions.

It has been the common practice to inject water into the cylinder for the purpose of promoting proper combustion. This feature has been eliminated in the newer types of the Fairbanks-Morse engines, which are now manufactured upon what is designated as the dry type. It is claimed by the manufacturers that the effect of the water injection was to form oxide of iron in the cylinders, which rapidly wore out the cylinders and plungers.

It will be interesting to note the action of the dry type relative to this feature.

In the types which are considered as small pumping outfits, designed to pump the water for communities of from 1 000 to 10 000 inhabitants, the engines required ranged from 25 to 150 h.p., but in the writer's opinion there is a large field for a still larger oil engine, and there are some machines now being produced that show wonderful efficiency in operation. They are of the Semi-Diesel type but are able to operate on the poorest grade of fuel oil and even tar products which have to be heated before it is possible to get them into the cylinders. The oil used runs as low as eighteen degrees Beaumé, while in the smaller machines, that is, below 60 h.p., the writer knows of good results with oil heavier than twenty-six degrees Beaumé, and with 25-to 35-h.p. engines kerosene or light oils of that grade have seemed to give the most satisfactory results.

Pre-war prices ranged from 2 cents to 7 cents for the various grades.

The ordinary time of starting with fuel oil is from twelve to

eighteen minutes, but engines of this type may be equipped with apparatus which permits of instant starting by electric ignition and gasoline, turning on the fuel oil after a few minutes, without interruption of the operation of the engine. This latter contrivance is of especial value where but little storage of water is possible and pumps have to be operated in case of fire, as the delay in heating the cylinder head may be serious if the supply of water is not available.

It is claimed by the advocates of the electric motor in comparison, that the motor requires little attendance, while the oil engine calls for constant supervision. This claim is not entirely substantiated in practice, for many of the oil plants are operating for long periods of time without attendance. With a suitable system of lubrication and proper safeguards, there is undoubtedly a great saving in most cases by permitting the plants to operate without attendance. It is true that breaks will occur and lubrication will fail at times, but the resulting damage is insignificant compared with the cost of wages for constant attendance.

This of course assumes that there are duplicate units which will take care of any fire hazard if repairs are necessary. It should also be considered that constant attendance does not eliminate many of the breakdowns.

Perhaps the most satisfactory combination that can be installed for a small pumping plant for general municipal needs is made up of two duplicate units of which it is probable that the fuel-oil engine meets the needs fully as well as any other drive which has been developed up to this time.

A convenient arrangement, which the writer has found very effective, is to place two vertical Triplex pumps geared to two pinions running upon the same jackshaft, the jackshaft being in the line of the main shaft of the fuel-oil engines which are placed at each end of the pumps. The connection between the engine shaft and jackshaft is made by clutches which permit either engine to operate either pump. This establishes a system which can meet most any condition that is liable to occur in the way of breakdowns without interrupting the service.

Another combination which is satisfactory and meets the requirements of the insurance authorities with a little saving in first

cost is where one or two pumps are driven by a fuel-oil engine and an electric motor so arranged as to be thrown into operation alternately as desired. The low cost of the motor saves something on the first installation and the daily operation can be taken care of largely with the engine while the motor is used for the emergency unit.

PUMPING PLANT, MEDWAY, MASS., WATER WORKS.
(Meitz & Weiss Oil Engines.)

One advantage which is of considerable importance in some cases that steam machines have over most of the other types is in the varying of speed in operation. The speed in the electric motor and of the internal-combustion engines is variable only to a small extent except by change gears or belt pulleys, and it is sometimes necessary to pump to waste or through a bypass back into the suction, an uneconomical process, in order to keep the rate of delivery as desired.

It is possible that one of the triumphs of the future engineer is

the invention of an internal-combustion engine which will have the same flexibility as to speed of operation as the steam engine.

The writer had occasion, a short time ago, to make a comparison of different types of pumping plants to determine which plant would best meet the needs of a community. In connection with this, the results of investigation of different units were tabulated and are here given.

The figures in this table are not, of course, to be considered as exact costs, either of operation or first cost, but are the results obtained by using quotations and guaranteed efficiencies by the manufacturers of the different lines of machinery. The estimates are subject to all kinds of variation but are intended to give a fair average ample cost of machines suitable to the particular work to be done.

These figures were also taken before the extreme rise of prices which has occurred since we entered the war, and while they are far above the averages of five years ago it is probable that they are nearer what we may expect in the next few years than pre-war prices. In general, the figures given are intended as a comparison, and the writer believes give a general idea of the comparative costs.

The question of size of the pumping engine is really a problem of the capacity of the pump except to provide sufficient margin of power to drive the pump under all conditions of loads which may be brought upon it. It is usually the case that the rating given for motors and engines by the various manufacturers contains sufficient margin of safety to be able to meet all demands, even if the load slightly exceeds that which was originally estimated. The proper size of plant is a matter which has been reviewed frequently, but there seems to have been some variation of opinion as to the most satisfactory capacities for various small plants. In the writer's experience, he has found danger of underestimating the convenient size and has had the most satisfactory results where the plant has been designed to pump the estimated daily consumption at the start in about six to seven hours, as the inevitable growth of the plant and increase in consumption will lengthen the time of operation. This gives a margin to provide for the period of pumping which might otherwise require more than one shift.

TABLE 1.

1 500 G.P.M., 250 Ft. Total Head, Operating 300 Days per Year, Nine Hours per Day. Theoretical H.P. 94.7.

Pump.	Drive.	Per Cent Eff. Pump.	H.P. Required.	Cost of Fuel per H.P.-Hr.	Total Fuel Cost. Per Hour.	Total Fuel Cost. Per 300 Days.	Estimated Cost of Plant.	Remarks.
Vert. triplex	Fuel-oil engine	85	112	$0.004	$0.498	$1 209.60	$17 188.60	Guarantee — 1 h.p. for .55 lb. fuel oil per hour. Price fuel oil, 4c. per. gal.
Centrifugal	Fuel-oil engine	71	134	.004	.536	1 547.20	16 342.70	
Vert. triplex	Steam turbine	85	112	.0075	.840	2 268.00	13 657.00	Coal at $6.00 per ton (2 000 lb.)
Centrifugal	Steam turbine	71	134	.0075	1.005	2 713.50	9 957.00	
Vert. triplex	Electric motor	76	125	.0124	1.55	4 185.00	11 115.60	Efficiency is combined pump and motor. Electricity cost, $\frac{9}{10}$c. per h.p.-hour plus "service charge" of 77c. per h.p., based upon max. h.p. in use, per month.
Centrifugal	Electric motor	64	148	.0124	1.84	4 968.00	6 248.00	
Cross compound, fly wheel, steam pumping engine						1 350.00	17 000.00	
Compound-Duplex-Deane steam pump — (Original plant). Rate about 700 g.p.m.						2 725.61		Actual figures of present cost. Rate of pumping about 700 g.p.m.

No fixed rule can be made, however, which will meet all cases as the rate of growth is widely different.

No study of power engineering can be made without awakening the greatest admiration for the wonderful work which has been done, first in the attempt to find some way of producing motion through machinery, and, in the gradual evolution of power production through the development of the steam engines, the internal-combustion engines, and the electric motor. The progress has been wonderfully rapid, and seems to be accelerated as time goes on in discovering and putting into operation new methods of getting greater power and greater efficiency. The discoveries of the last few years as to the great volume of oil to be extracted from the rocks of vast ranges of mountains in Wyoming and adjoining states give us more courage to continue development of the oil engine, as it is probable that fuel for its operation can be found in sufficient amounts to take care of the world's consumption, although rapidly increasing, far into the future.

Discussion.

President Davis. This is an exceedingly interesting and instructive paper. I want to ask Mr. Symonds one question. I notice one of the evident advantages of an internal-combustion engine is the fact that a licensed engineer is not necessary to run it. I wondered whether it took, in general, a higher grade of man than is necessary in a steam-operated pump. And, Mr. Symonds, what your experience has been in the way of repairs and maintenance, — whether repairs have been easily and economically made after an accident, or whether you have had the experience that some of us have had when our automobiles got into trouble.

Mr. Symonds. As regards the class of men that operate engines, we employ men who have good general mechanical ability, not licensed men. In small water-works plants it is often desirable to have an operating engineer who is also a good business man and can look after the general business of the department or company and frequently one man is able to do all the

local work. It is of advantage not to require licensed men, because some of the men employed in this work are excellent business men and have fair mechanical ability but would not be able to secure licenses for operating steam plants, although entirely capable of operating internal-combustion engines.

As regards the question of repairs, my experience has been that in general the fuel-oil engines have stood up without a serious amount of repair. There are more parts in an oil than in a steam engine, and consequently more complications, but in most plants the repair costs have been very low.

PRESIDENT DAVIS. Has there ever been any trouble in getting it done, or finding anybody who could do it?

MR. SYMONDS. We have not had any trouble of that kind. I have occasionally had emergency calls, to get repair men instantly because of some peculiar action of the engine, but they never have materialized as serious troubles. Usually, as in the case of the automobile engine, some insignificant feature was the cause of the whole trouble, which, when discovered, was very readily corrected.

MR. FRANK L. FULLER.* I should like to ask Mr. Symonds if he has any record of the cost per horse-power hour for the different fuels which he has spoken of with engines of this moderate size. For instance, electric current, fuel oil, and steam. How they would compare.

MR. SYMONDS. I think the table presented, which estimated the yearly costs, furnishes such a comparison. There are an infinite number of conditions, and unless you take one set of conditions and figure it out, taking identically the same basis, you do not get a perfect comparison. For the small machines, purely on the basis of fuel costs, the producer-gas engine operates at about the lowest cost of any type which has come to my attention. Wherever we have made comparisons the cost per horse-power hour for producer-gas engines has been very low.

MR. FULLER. Well, from your knowledge, experience, and records, probably such a table as I speak of could be figured out. That is, from your records of a year's running the cost per

* Civil Engineer, Boston, Mass.

horse-power hour for any particular plant could be figured out fairly accurately, or perhaps very accurately.

MR. SYMONDS. Yes. Such a comparison, while only approximate, is made in the paper presented.

MR. CREED FULTON.* What did you have as the fuel cost per horse-power hour in the table that you used?

MR. SAMUEL A. AGNEW.† I understood that that table showed the cost to be about .459, meaning almost a half cent per horse-power hour, as I recollect those figures. That is what they generally figure.

MR. SYMONDS. Yes, the table gives as a comparison about a half cent — .4 — per horse-power hour for fuel-oil drive; about twice as great for the steam turbine, and about three times as great for the electric motor in that particular case.

MR. FULLER. I think, as I remember it, our pumping plant at Wellesley showed a price, five or six years ago, — before the price of coal increased as it has, — of about a half a cent per horse-power hour. Of course it would be more now.

MR. G. HOWARD HAYES.‡ Perhaps I can add one or two figures to those of Mr. Symonds. We have a plant which was installed about four years ago which compares very closely as to pumping conditions with the centrifugal pump of which Mr. Symonds spoke. This is a 1 000-gal. Triplex pump driven by chain from a 100-h.p. electric motor. The average head is about 106 lb. Fairly close records have been kept of this pump. Just about a year after it was officially tested it was tested again to see how it was maintaining its efficiency. The official test showed an efficiency of slightly over 77 per cent. That is, taking the water pumped into the standpipe against a head of from 102 lb. to 112 lb., and the electricity consumed as shown by the meter.

The second test showed practically the same, that is, 77 per cent., or a little more. I have some of these figures here. The average head was 106 lb. The pump ran 8 840 revolutions, and in doing so pumped 216 796 gal. and used 220 kilowatt-hours of

* Goulds Pump Co.

† Superintendent Water Works, Scituate, Mass.

‡ F. H. Hayes Machinery Co.

electricity. That place is obtaining its electricity at a very small rate. It is only 1.8 cents per kilowatt-hour at night. That gives a cost per thousand gallons pumped of only 1.15 cents, which compares with the centrifugal unit which Mr. Symonds mentioned of 2.8 cents.

A test was also conducted a year after that, the third year, which showed practically the same results. I hope we shall be able to have another test this year to show how it still holds up; but as a general thing I think I can say that the Triplex pump will always justify its additional cost over the centrifugal where economy of operation is the primary item. Do not understand me to say that a centrifugal pump is not a proper pump under some circumstances — it is, but especially where large volumes of water and low heads are encountered. Very seldom will the centrifugal pump be the best pump to use on water works, especially on variable heads as pumping into standpipes. I am not speaking from a prejudiced point of view in favor of the Triplex: we are interested in both — have both of them — and the Triplex pump will justify its extra cost. Also, if we turn to the oil engine we generally find the oil engine will justify its cost over the motor.

In the case of the oil engine we can generally assume that the oil engine will show a duty per gallon of fuel used — that is, actually burned in the engine — of from 14 000 000 to 15 000 000. Sometimes it will run a little less and sometimes it will run more. I know of one case where the average duty per gallon is 18 000 000, and that in a place which would compare very favorably with the small plant Mr. Symonds mentioned.

Possibly the people in this place are especially favored with their operator, because I really think he knows more about the engine than the people who built it. It is an exceptional case so far as the man who runs it is concerned. But on the basis of 14 million or 15 million duty for fuel oil I think you will find that the average cost of operation of an oil engine is about one-third of the average cost of electric operation of the same pump with what is ordinarily called upon to be paid for electricity.

Mr. F. H. Hayes.* Mr. President, if I may be permitted, I should like to answer Mr. Fuller. Mr. Fuller's question was in

* F. H. Hayes Machinery Co.

regard to the cost per horse-power hour. If you can buy oil for eight cents a gallon, it means a cent per horse-power hour; if you can buy it for four cents it is one-half cent per horse-power hour; if you buy it for twelve cents it is one and one-half cents per horse-power hour. You can use oil at 6 cents per gallon. To meet it in electricity you have to buy it for less than one-half cent per kilowatt hour. Those are things that we are in a position to prove, as we have had to prove them in the past.

I am very glad that Mr. Symonds has brought up this subject that he has. I have been trying it for twenty-five years. Some of the gentlemen who are here are using machines that were put up many years ago. There was one installed in Cohasset, probably the first one that was ever applied to a pumping engine. That was a Hornsby-Akroyd engine. It is now in operation, but it is a good deal like the old lady's stocking. There are a good many parts of it that have been renewed but the fly-wheels are there and running to-day. That particular one I think runs more in the twenty-four hours and in the year round than some of the others, for the reason that when they start it up they never stop it unless it stops itself. An oil engine is wiser than a man; it will stop if it is overloaded, and a man won't. There have been so many different kinds of this combustion engine brought before the public that it has been necessary to study it. The first was the Otto. It uses gasoline beautifully. There are a lot of them that will use gasoline beautifully. Then they went from that to kerosene. Then they go from that to a cheaper fuel. There are engines that have been built for using a cheaper oil. There are engines that are sold for the cheaper oil that work better on kerosene oil and on gasoline. I imagine that some of the gentlemen who are here know that I am telling that which is so. The condition surrounding the fuel oil is that there are more B.t.u's in it. If you go from that to kerosene oil, that which is called "solar" oil, there are some of the heat units taken from it. When you go from solar oil to kerosene you lose some of the B.t.u's, and when you go from kerosene to gasoline you lose some of the B.t.u's. And also in the gasoline, the evaporation of the gasoline itself does not produce power but it does cost you money and is a charge against the plant.

In regard to the use of an engine without care — that is, care all the time — it may be answered in this way. There are three engines in a particular place, and there is a standpipe up on a hill. The gentleman goes there at night and sees what his pressure is, judges how long it will have to run to fill it up, fills his fuel tank with oil, and when that oil is run out the tank is full and the engine stops. That same engine I have known to run four weeks without a stop. So that the record of the oil engine used in connection with the small pumping plant is worthy of the consideration of you all.

MR. BERTRAM BREWER.* We have no bias toward any particular type of pumping plant, but there are certain advantages in electric pump operation, especially in a small plant, which cannot be gainsaid.

Of course the cost of power is high, especially in comparison with an oil engine, but past experience indicates that electric power is more likely to decrease than increase in cost in normal times. The electric plant can be operated absolutely automatically with a minimum of risk to the machinery, and the depreciation of a well-made motor is not a big item. Where frequent starting and stopping are necessary, automatic control, by cutting out practically all labor expense, puts the motor in a class by itself. A stand-by unit, preferably of the oil-engine type, furnishes a reliable alternative power in case of a breakdown, and makes the second factor in a remarkably good combination when the odor and noise are not objectionable.

Attention is called to the fact that the towns of Ashland and Amesbury have recently substituted electricity where an oil engine had been used. The authorities at Ashland concluded that they could more readily secure the greater flexibility which they desired from the motor. Longer life and more years of service are expected. This reminds us that in certain cases flexibility outweighs every other consideration, as it is often necessary in some plants to secure every last gallon of potable water in time of drought. As there is every prosoect, therefore, of more and more automatic pumping and in larger and still larger units, and

* Assistant Engineer, State Department of Health.

since the saving of labor is so vital a matter, the following notes bearing especially on the details of automatic pumping by electricity may be of use to some one who has such a plant to design.

Many small electric pumping plants are operated more or less automatically to-day, whereas ten years ago when the writer designed and built one they were almost unknown, at least in municipal practice. In this particular case, which was a sewage-receiving well in an outlying district, frequent starting and stopping were necessary and cleanliness and quiet were indispensable. A noisy, bad-smelling exhaust was prohibitive.

The important features to be considered in automatic pumping with electricity may be summarized under the following five heads:

1st. Proper automatic acceleration of the motor to its full load.

2d. Protection of the motor against a sudden dangerous diminution of power.

3d. Protection against overload.

4th. Precautions respecting temperature changes and humidity.

5th. Provision for keeping the pumps and their connections free from air pockets.

Just a word of explanation concerning each of these five points:

1. *Efficient Automatic Starters.* Starters that reliably provide for automatic acceleration of those motors large enough to require starting torques less than full load torques have been on the market for some time and are satisfactory. This feature may be said to be well in hand.

2. *Protection against Fall in Voltage.* In one plant which has been operated for ten years and was installed without automatic protection against fall in voltage, a failure or rather loss in current has twice caused the motor to burn out. While the motor did not receive enough current to revolve and ventilate it, it did receive enough to heat it up sufficiently to melt the windings. Each time, however, the power company acknowledged the fault and paid for the repairs, as it was due to grounding of wires in a storm in one case and careless handling by the power company's men in the other. In recent years sudden fall in voltage has also been met by appropriate devices that shunt off the current automatically.

3. *Overload Protection.* Of course fuses have always been used

to guard against overload, but they have not always proved sufficiently flexible. We understand, however, that the latest type of starters are supplied with a self-contained and more satisfactory overload protection.

4. *Precautions against Meteorological Conditions.* The question of heating the building containing the plant has always been an important one. Starters can be obtained to control the pumping from an open well that work in all kinds of weather. Care must be taken, however, to place pumps and water-filled pipes well below frost line. Arrangement of the wires that control the float and starter must be such as to allow for their possible contraction or expansion. Care must also be taken to prevent the twisting of these wires in cold weather. Furthermore, a kind of oil that will not congeal at low temperature must be used.

Plants in a closed pressure system must be continually maintained above the freezing point by artificial heat. Considerations of humidity point always to a distinct physical isolation of that part of the plant that controls and furnishes the power, as the best design, though it has not always been found necessary.

5. *Air.* The fifth and last difficulty, — that of air in the water line, — unless carefully guarded against, will upset all plans for remote control.

Finally we present a list of some of the municipalities near Boston where there are pumping plants operated by electricity. Some of them are more or less automatically controlled:

Water-Works Systems.	*Sewer Systems.*
Weston.	Newton.
Ashland.	Waltham.
Lawrence.	Clinton.
Newton.	Worcester.
Lynn.	Boston.
Norwood.	Hudson.
Fall River.	Milford.
Wellesley.	Andover.
	Maynard.
	Norwood.

Mr. Fuller. There is a little plant at West Groton, Mass., where there is a motor-driven pump which is started automatically

by an arrangement whereby a clock turns the current on and off, so that by an adjustment the pump is started, we will say, at seven o'clock in the morning, and shut off according to the demand for the water. I understand this has always worked very well.

President Davis. I want to ask Mr. Hayes whether the oil engine has been used to any extent as auxiliaries at big stations.

Mr. F. H. Hayes. I do not know of any around here, but there is no reason why it should not. Any of the steam-driven units in the pumping stations which will operate any of the vertical Triplex pumps will take 40 lb. of steam per horse-power hour, and that runs up on the coal bill pretty well. Now, you take an engine that will run that same auxiliary. It will produce its horse-power per pint of oil per horse-power hour. That is on the smaller ones. When you use the larger ones you get down to .75 of a pint per horse-power hour. Does that answer your question?

President Davis. Yes.

Mr. F. H. Hayes. I might answer the other question which you asked Mr. Symonds, in regard to reliability. That particular engine that he showed us on the slide — it is a fact that that particular engine, of 80 horse-power, ran for one year and was not stopped but twenty minutes. So that the repair part of it was not much.

Mr. A. O. Doane.* When making plans for the smaller stations for the Metropolitan supply we investigated all of the types of pumps which have been mentioned here this afternoon. Some of the things which we went into may be of some interest. One of the points that I have not heard mentioned here in connection with the oil engines, gas engines, and producer-gas engines, is their applicability to stations which are situated in residential neighborhoods. We have some small stations situated in such localities, with particular neighbors, and they are pretty fussy about what goes on in connection with the smells and noises, particularly in the night. And our investigation of producer-gas and oil engines showed that it was very difficult, if not impossible,

* Division Engineer, Metropolitan Water Works.

to so reduce the noise from the exhaust by a muffler, that it would not be objectionable to near neighbors.

There is another objectionable feature in producer-gas plants, and that is a strong smell of gas apparent at all of the plants, even in spite of steps which have been taken to prevent it. It seems to me it must be very disagreeable and injurious to the help, and in the summer time the neighbors might smell considerably more gas than they wanted to.

We have in one district a plant of less than three million capacity, and when we took the matter of electric operation up with the Edison Company they were unable to show us any economy over the steam operation, even when compared with a small direct-acting pump, which we all know is rather wasteful in the use of steam, unless the attendance could be cut right down to the bone, — in fact, almost to automatic operation. As our stations are the main reliance for fire protection and some of our standpipes and reservoirs are located where it would make considerable trouble and cause damage if they overflowed, we did not feel justified in taking the risk of automatic operation.

There is also a danger in electrical operation, even if you have duplicate units, that something may happen to the overhead transmission lines or to the generating plant. I know of a case not far from Boston where an electric pump operated a drainage system by pumping out a sump too low to drain by gravity to the sewer. One day a very heavy storm came, and a flash of lightning struck the power station, knocking out that particular section that fed this place. The consequence was that the pumps stopped, the drains overflowed, and water got into the basements causing several thousand dollars' worth of damage to goods.

Undoubtedly the electric motor for small plants, where the responsibility is not too great, is almost the ideal thing. We have one pumping sewage to filter beds which is semi-automatic. It is started by an attendant at the filter beds on his way to work, and when the sewage is pumped down in the collecting well the pump automatically stops. In this particular case entire automatic operation was neither necessary nor desirable, for it was better to put the sewage on to the beds when the attendant could be there to see that it was properly distributed.

In regard to the question that was just brought up about auxiliaries in steam plants. In the case of most water-works plants, condensing-steam machinery is employed and in the steam-pumping station, especially if auxiliaries directly connected to the main pumps are used, it is generally pretty hard to get enough waste steam or exhaust steam of high temperature to heat the boiler-feed water, which condition would be aggravated by using oil engines, which would not furnish any source of heat except possibly a little from the cooling water.

MR. F. H. HAYES. May I answer Mr. Doane in regard to the heating of the building by an oil engine? It is possible and it is done. I have also in mind another place where in the installation of a small water-works plant in Maine they put in a steam pump with a boiler. They put in a boiler and an oil engine. The conditions surrounding were such that they could not get wood to fire the boiler, and they put up electric wires through the woods with the result that the wind came and blew down the wires, so they started up the oil engine and it has been running ever since.

MR. REEVES J. NEWSOM.* I have had some experience in comparison of oil engines with motor-driven units, and in two cases in particular the motor-driven unit was the more desirable. These plants were for the city of Lynn, and while they are considerably larger than those described in Mr. Symonds' paper, the one being 15 million gallons a day and the other 20 million, there are two considerations which entered into these problems independent of the size of the unit. Both of these plants — one is in operation and the other is only proposed — are for use of the supply into the system. That is, the pumping of water from the rivers into the reservoir. And in both cases the pumping takes place in about three months in the year. And under those circumstances the fact that the oil-engine installation is considerably larger in its first cost made the motor-driven unit more desirable even had it operated at considerably higher cost. The operation, of course, only went on for three months, and the interest charges on the first investment went on for the twelve months. Then both of these plants were more or less isolated, being out on the

* Superintendent Water Works, Lynn, Mass.

reservoir system, and it was desirable, if possible, to have units which we could operate with a very low class of attendants. We have operated the one plant and will the other with men who are only watchmen, patrolmen on the reservoir. I do not think that it would be advisable to intrust the operation of an oil engine to this type of attendant.

PRESIDENT DAVIS. Do you have to pay stand-by charges on your electric current? You said you operated for three months in the year; do you have to pay stand-by charges for the remaining nine?

MR. NEWSOM. No; we have a minimum charge on the one station that is in operation of $1 000 a year, but it only requires fifteen days' pumping to eat up this minimum charge, and it must be used for pumping at least that amount. So that there is no occasion in our case for us to pay a minimum charge for which we get nothing.

MR. T. G. HAZARD, JR.* There is another point in connection with this subject that has been of a little interest to me, and that is the question of whether the hammer in the pipes is the result of the use of a one-cylinder oil engine. I have operated a couple of these 25-h.p. internal-combustion engines, and we have had some trouble with water hammer since they have been in operation. I would like to ask if anybody else has had that same trouble. Most everybody remembers a time about ten years ago when the first automobiles were in practical use, that it was a choice between a steam engine and a one-cylinder gasoline engine, and any one who has tried the two types remembers the different feeling in riding with a very smooth-running steam engine and a very jerky one-cylinder gas engine. I have found that the pulsations of the pump are apparent at a very great distance from the pumping station where a one-cylinder, internal-combustion engine is used.

PRESIDENT DAVIS. What kind of a pump have you?

MR. HAZARD. Triplex.

MR. SYMONDS. In connection with the subject of water hammer, several cases have come to my attention, but in no instance have we been able to hold the engine responsible for it.

* Civil Engineer, Narragansett Pier, R. I.

I have in mind three cases; the first of these caused extreme vibration in the pipes in a factory, and in dwelling-houses in this particular section. The water supply in this case was gravity, and the particular section where the trouble occurred was under about 110 lb. pressure. It was finally traced to an old duplex-boiler feed pump, which was badly out of repair, and was sucking air. This pump was pumping directly from the mains. The trouble stopped as soon as the pump was put in order.

The second case was also on a gravity system, and has never been fully explained so far as I know. Continuous hammering occurred at the end of a long 8-in. pipe about a mile from the reservoir. We could find no pump connected with this pipe. I suggested the use of air chambers as a possible remedy, and have not heard from the case for some time, so this may have solved the difficulty.

The third case is on a pumping system, about one mile from the pumping station on one of a series of side streets leading off from the main line. The plumbing in one house at the end of this line has continuous vibration when the pump is operating. This street has been practically shut off. In this case the pumping is by a Triplex pump driven by a De La Vergne single-cylinder engine. It is a strange fact, however, that the vibration occurs in no other point in the system, although there are numerous streets similarly situated, and it is also practically all at one house.

Mr. F. H. Hayes. It is suggested that the cause of the water hammer can't be laid to the oil engine, but it is a possible thing that the water cylinders of the pump do not fill full. If they do not fill full they will water hammer.

Mr. Fuller. At Marblehead, some years ago, there was a tremendous amount of water hammer in the upper portion of the old Forest River Lead Works building. It was thought perhaps there was air in the pipes and every effort was made to remove any air that might be there. I do not know whether the trouble was finally eradicated or not. There was one other house in Marblehead where they had a good deal of trouble from water hammer, but I do not know how that ended. That was from a steam pump that was located not very far from Forest River. None of the engines which have been spoken about were

used. At Wellesley there is one particular place on a side street where, when we changed from the regular pumping engine, which was one of the original duplex pumps, there was trouble of this kind. When we changed back again to the regular pumping engines the trouble seemed to stop. It has always been a mystery what produced the water hammer in those places which were off the water main. I think there is a good deal of difficulty about removing those causes.

Mr. C. W. Fulton. I happened to be the goat, a few years ago, in looking up troubles. I am rather inclined to think, in the case of this oil-driven engine pump, the trouble is probably in the suction side of the pump. Sometimes the pump won't take its suction uniformly. And, as Mr. Hayes said a few minutes ago, the cylinders on the upper stroke of a single-action pump won't fill completely, and they hit on a partly filled cylinder and you would think the pump was going off the foundation. I think in this case the water hammer may have been due to that because of poor regulation on the part of the engineer.

Mr. A. O. Doane. We had a case where there was no trouble whatever in the station when operating a direct-acting pump; it seemed to be going along as smoothly as possible, yet there was considerable noise in certain parts of the pipe system, and it seemed to be due to running the pump at certain speeds. At one speed it would be very much worse than at another. And we had never been able to find any very satisfactory remedy for that condition excepting to be careful to run the pump at a speed which would make the least trouble. But as it is a reserve pump it does not very often trouble us anyway.

The answer to that certainly is the centrifugal. The centrifugal does not cause any shock, so far as I know. And furthermore, I think that if you have occasion to pump into the mains directly, without any standpipe, reservoir, or other outlet except the services, the centrifugal is nearly the ideal machine, for it is automatically regulated. That is, if the centrifugal goes at uniform speed and the pressure drops when a big draft of water comes, the centrifugal automatically pumps more water as the head drops. And the converse is true, — if the pressure runs up the centrifugal pumps less water. In this way it acts as an automatic regulator,

even when running with a constant speed motor. It would not do any harm if the discharge outlet was closed altogether.

PRESIDENT DAVIS. Heat it up?

MR. DOANE. Yes, it would heat up but would probably do no serious damage to the pump.

MR. LEONARD METCALF.* I have been very much interested in this excellent paper of Mr. Symonds and the admirable discussion which we have had after it, because it serves to bring home the complexity of the problem of the small pumping station. I think in many ways it is a much more difficult problem than that of the big pumping station, because you have not the financial resources with which to work.

One can't review the work of one of our old and valued members — Mr. Freeman C. Coffin — without having one's admiration aroused by what he did in the development of these small pumping stations.

I am sorry that Mr. Agnew is not here, because he might add a word in regard to the situation at Scituate. But there are various papers in our JOURNAL which perhaps have covered that ground fairly well; and there are other members, I think, who have become very familiar with the Hornsby-Akroyd engine, as it has been used at a number of other stations. The main lesson which it teaches, as I see it, is the lesson of comparative reliability in the case of a small water-works plant, even though the attendance of labor — that is, the amount of labor — expended on the plant be reduced to the minimum.

I have been very much surprised, in going over the records of the Scituate Water Company, to see how cheaply it has operated its works, because, though there are three pumping stations (one of them only is operated during the winter season ordinarily, and the other two, during the summer season, when the summer colony is there and increases the population of the town from about two thousand to about thirteen thousand people), nevertheless they are able to operate the stations with very little labor. The pump is oiled, started, and taken care of in the morning, the key is turned in the door, and the station is allowed to run itself until the oil supply gives out.

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* Metcalf & Eddy, Boston, Mass.

That brings home to us the importance of reliability, and I rise merely to add a little emphasis to the comments of several other speakers in regard to the subject of reliability, because, after all, the operation of the water works is a function touching the public interest. If the works are corporately owned, and fail for even a couple of days to render service, they may undo the work of five or ten years in the building up of the public good-will. And I might say that in the case of the municipal works, of course, any serious trouble of that sort usually results in a change of administration.

It brings home to us, then, this fact, that the reliability of the type of plant proposed is of great importance. I noted this in an interesting way at San Antonio, some years ago, where for the high-service plant, drafting water from wells, and pumping intermittently, it was suggested that a pump of the steam-turbine-driven centrifugal should be used. The stock of the company was owned in Belgium; the bonds, in this country.

A Belgian engineer reviewed the plans which we had prepared and made the suggestion that Diesel engines should be substituted for the engines suggested, on the ground of economy, and stated that he had used them very successfully both in large and small plants in Belgium. My reply to him was that I recognized their economy, but the difficulty was that we had not yet, in this country, developed a sufficient number of men familiar with the Diesel engine to make me feel safe from a practical standpoint, and that an interruption of the service for the length of time required to transport a man who knew all about the Diesel engine and its difficulties, when he might be needed, from the point from which he could be obtained, to San Antonio, was too long; in other words, we could find, locally, many men who were capable of running a steam engine, an electric motor, or an oil engine, where we could find none familiar with the Diesel engine. The Belgian engineer accepted this explanation as being of controlling importance. The company finally installed the type of pump suggested (De Laval units), and has had continuous operation and successful service from it.

The same question of reliability is met in all of these smaller plants, and the difficulty is tided over in many ways, as for in-

stance by enlarged reservoirs, or, if there be more than one pumping station, by the fact that greater safety grows out of the duplication of plant in several pumping stations. And those factors will be of importance to you in making decision as to which type of machine you will put into use. The labor problem, which has been alluded to, is often a controlling factor. I think it has been my experience that, as viewed from the power end only, you generally have to get electric current for one cent a kilowatt-hour or less in order to compete successfully with the oil engine, and generally substantially less than one cent. On the other hand, when you take into consideration the labor factor the difference may be less. In other words, you can afford to pay more for your electric current and still use it advantageously. And if the question of intermittent use comes in, and cost of labor, as has been suggested here, then the electric motor may be more advantageous than any of the other types.

Each problem will have to be settled on the merits of the case, or, rather, on the circumstances which attend operation. The difficulties of the problem are those attendant upon expense. I think that the men who have handled these small works successfully, financially, deserve great credit for the way in which they have solved their problems.

MEETING WATER-MAIN COSTS BY ASSESSMENTS FOR BENEFITS.

BY M. N. BAKER, ASSOCIATE EDITOR, *Engineering News-Record*, NEW YORK.

War and prohibition have joined hands in making the financing of municipal improvements difficult. Bond issues cannot be piled up nor taxes incurred without limit. New sources of municipal revenue are being looked for. Old methods of raising funds must be utilized more fully.

Assessments for benefits as a means of meeting the cost of streets and sewers is an old and well-tried practice, supported in most if not all states by a sufficiently long line of judicial decisions to put it legally beyond question. In recent years benefit assessments have been applied to other improvements than streets and sewers, — notably to parks, — and they have been proposed if not actually legalized for rapid-transit extensions in New York City. A few cities meet, or have met, the cost of water-main extensions by levying the cost on abutting property. Is this sound policy? If so, why not adopt it more generally? I raise these questions not to support or oppose water-main assessments but to make a starting point for discussion by practical men who are daily confronted by such questions as revenue guaranties for mains extended into sparsely-settled districts or to a lone house at the end of some long street.

Before going further with water mains, it may be well to state briefly the underlying principle of benefit assessments. It is that a given public improvement renders a measurable benefit to all the property actually or potentially served by it, a benefit that increases the value of the property. The cost of the improvement may therefore be levied on the property in proportion to benefit, but not in excess. As a legal safeguard, some part of the cost is often placed upon the city as a whole. This may be fixed

arbitrarily by state law or local ordinance, or it may be determined for each case by the commissioners or assessors who fix the assessments.

Unfortunately, most assessments are made by some rule of thumb, or follow old practice because it has been given court sanction. Rarely are assessments based on sound engineering and economic principles. What these principles are and some of the details of their application were stated twenty-five years ago by F. Herbert Snow, then city engineer of Brockton, Mass., in a report on sewer assessments which remains unsurpassed to this day.

Mr. Snow's report is of particular value to water-works men because it considers water supply in relation to sewerage and sewage disposal, and because it outlines a plan for distributing the entire first cost of a sewerage system between the property benefited — divided into public benefit to the entire city, and private benefit to the individual property owner — and because it proposes a yearly charge for the use of the sewers similar to a charge for water. In further detail, the report goes into the relative merits of frontage and area assessments and, as I remember it, recommends a combination of the two. The scheme was put in use by the city of Brockton, and it or a like one was in vogue in several other New England cities a short time afterward, as witness a symposium on sewer assessments before the Boston Society of Engineers some twenty to twenty-five years ago — printed in the *Journal* of the Association of Engineering Societies.

As I have said, I neither advocate nor oppose paying for water-main extensions by assessments for benefits, but I think that any city which is puzzling over meeting the cost of such extensions might well study the plan. It might be particularly advantageous for small towns just building works.

Discussion.

Mr. Caleb Mills Saville.* *Mr. President and Gentlemen,* — The matter of Mr. Snow's report on Sewerage Assessments at Brockton, Mass., was mentioned by Mr. Baker, but he did not mention another valuable report along those same lines, made some years ago by Mr. Frank A. Barbour of this Association, in connection with sewerage assessments at Peabody. About a year ago, I think it was, there was an article by Mr. J. J. Ledoux, published in the *Municipal Journal*,† dealing with the matter of assessments, in which he deduced that assessments for private water companies should net at least 25 to 30 per cent. of the cost before the extension was made.

In opening I might perhaps say that this whole question has recently been before the Hartford Water Board for consideration and being in New York one day I met Mr. Baker and discussed some phases of it with him. Mr. Baker immediately seized on it as a good subject for discussion before this Association and that is the reason for my appearance today. Perhaps I might tell you how it came up and of some of its perplexities in Hartford. The method there used is probably that which obtains almost universally throughout the New England States, although there may be some modifications. The cost is assessed, or not assessed, by finding what the cost of the extension will be, and then having the people who desire pipe, guarantee payment of this cost or some other definite amount. Sometimes payment is made in a lump sum; sometimes as a certain percentage of the actual cost — that is, the assessment is so divided that the total payment may extend over a certain period of years; sometimes a certain size of pipe is decided on sufficient for the needs of the street — perhaps a 6-inch pipe — and if a larger-size pipe than that is used the excess cost of the larger-sized pipe goes into the general fund of the water department, this being an improvement to the city as a whole. Perhaps every year the cost of the preceding year may be taken as the basis, and the cost of the coming year based on that. The reason for using a uniform cost was in order to be

* Chief engineer of the Board of Water Commissioners, Hartford, Conn.

† July 6, 1918, p. 9.

fair to all people. For instance, if a man were so unfortunate as to live on a rocky hill, he had to pay perhaps two or three times as much for the pipe as a man who lived in a good gravel territory, where it was very easy to put the pipe in, and it seems desirable so far as possible not to penalize people who cannot always overcome natural obstacles.

Originally in Hartford there was a 10 per cent. guarantee on the cost of installation. Now the petitioner guarantees 10 per cent. annually on the cost of laying an 8-in. pipe in that street. That is, an 8-in. pipe is the smallest pipe that we ordinarily put in, except in streets that are 500 ft. or less. In that case it is the cost of a 6-in. pipe that is used.

Now, the difficulty that has come to us — and I presume it is the difficulty that may be met in a great many other places — is that of a man who has a vacant lot on a street. There happens to be no city water main in that street, because the land was formerly owned or developed by a building promoter. At first one house was built perhaps near the end of the street where there was a city water pipe and application made for a service connection, which was installed. Then another house was built and connected by the owner to the first service pipe. That method was continued until ten houses were connected on a 1-in. service pipe, all the way along the street, the pipe being perhaps eight hundred or a thousand feet long. Then comes a man who has bought a lot on the street about halfway down. This man builds the house and suddenly thinks he would like some water. He starts out to find where his water is coming from and he finds this private pipe, to which he thinks he will connect, but encounters strong opposition from those now connected who say, "We have now no more than enough water for ourselves; you cannot connect to this pipe." He then comes to the department for information as to what can be done. He is told to get a petition signed to have a water main put into the street. The cost of an 8-in. pipe this year is estimated as $3.00 per running foot. If the house is 500 ft. from the present main the total cost would be $1 500, or at 10 per cent. per year $150, to be guaranteed annually less the cost of water used paid for at meter rates. The reply to this is that he can't afford to put a pipe into this street, as his

water rent would probably not exceed $18 per year. He is then advised to get his neighbors on the street to join in the guarantee. He goes to them, and comes back with the report that they are supplied with water and do not propose to take on his troubles under this basis. What is to be done? The householder manifestly cannot afford to pay, and at the present time assessment cannot be levied on other consumers on the street or on vacant land which is benefited if a main pipe is put in.

Another case has been brought up: A building promoter petitioned for and had laid about a thousand feet of pipe in the street; from that he took off branch pipes and carried them all around the developed area and the department put on three master meters through which water was supplied to 28 to 30 houses. The promoter collected from these a proportional part and paid the department for the water registered by the master meters. Year before last he had considerable trouble with freezing of the services that he put in. Some of the people that he sold water to used water pumps to drain out their cellars and some used a great deal more water than the others did, but objected to paying a very large amount for the water they used, and he had considerable trouble. He came to the department and said, "I have no more interest in this development; I have sold it all, and just notify you at this time that I intend to pay no more water rents. If you like you may take over my water system, but I have no more interest in it." Now, the department did not wish to take over this system because they would have on their hands about 2 000 ft. of 1½-in. pipe, and the minute they took it over it would be a city pipe and the people in that neighborhood would have called for an 8- or 10-in. pipe in order to get fire protection.

Now, as Mr. Baker has said, there are three or four ways of assessing benefits, and water supply in a street is a benefit undoubtedly, and a great benefit. One method of assessment is the frontage method. Offhand, one would think that was a fair way, to assess everybody on the street. All are benefited, and the vacant lots are so benefited that the selling price immediately is increased when water is available in the street. But in some ways this is not a fair proposition. You can conceive of a large vacant lot — a large farm, we will say — that the owners do not

propose to develop, perhaps, in the lifetime of the present owners, and yet beyond there is other land that the owners wish to develop. The vacant-land owner does not wish to pay for the installation of a pipe he will not use but, on the other hand, it benefits his land and increases its value.

Now, I am not yet ready to propose anything and just bring up these matters so that perhaps somebody will give us an answer or at least provoke discussion that may result in suggestions of value in meeting what now is a most perplexing condition. With the frontage proposition is a thought that Mr. Snow has very well brought out in his report on this matter, and that is that the front-foot proposition is not always a fair one. Suppose you have two lots, one of them perhaps 150 ft. long, with a private residence; adjacent is a small lot, perhaps 25-ft. front, on which is erected an apartment house of 6, 8, or 10 apartments, which will use three or four times as much water as the single house uses. In this case it is easy to see the frontage proposition will not always be fair or equitable to consumer or department.

Beside this comes the fact that it may often happen that there are rear lots, entrance to which is obtained by a passage from the main street; perhaps the passage may be only 15 or 20 feet wide, and yet in behind there may perhaps be a large area that could be developed. In the report of Mr. Snow there are all kinds of combinations that can be had and mention is made of these only to show some of the possible objections to the frontage plan.

The area plan offers some inducements, and perhaps the proper solution of the problem may be some combination of the area and the frontage assessments.

Besides the methods are the ways of collecting this assessment. The first method to be thought of usually is a lump-sum payment and its logical alternate, which is a method of deferred payments of the principal sum.

Another proposition is the case of corner lots. It is obvious that ordinarily a man will only take water from one street.

To get at the vacant-land owner, there is a possibility that, recognizing the hardship of paying an assessment on land that is not developed and bringing in a return, some modification might be devised. Possibly he might be required to pay something

when he did enter this water pipe, — perhaps not pay for what has passed, but for the future, and by then signing a guarantee to come in on the same basis that other people had come in on and so divide the burden with them. Perhaps some lump-sum payment might be required before connection would be permitted to one who had not signed the petition.

In most water departments at the present time another inequality in assessments presents itself. Suppose a main a thousand feet long, and a half-dozen people sign up and guarantee its cost. One man on the street, or two or three men, perhaps, own vacant land. They are approached by the people who want water and asked if they will sign this guarantee. This they refuse to do because they say they have no interest in it, they do not propose to build at present. In several cases, however, it has been found that after the pipe had been put in, these same people who refused to sign the guarantee immediately built, and the pipe being a city pipe, they have a perfect right to have entrance to it. They enter on that pipe and have all the privileges that accrue to the original people with none of the responsibility of guaranteeing its cost.

One other matter that comes up in this guarantee business is the effect of development propositions. Many builders will apply for extensions, and be perfectly willing to put up the guarantee. They are outside concerns, however, over which the city has no control. After building the houses they will sell them. Of course this guarantee is a lien on the estate to a certain extent, but the builders may not be responsible. Just at present in Hartford a bond for payment is required from these outside promoters.

As stated in the beginning, the matter of amounts for installation of extensions of water mains is a most perplexing one. It is, however, of very great importance to the department, especially at the present time. On the one hand, the department finance must be consulted, and no additional burden placed on present consumers which is not proper or fair to all. On the other hand, as it is desirable to encourage building development as much as possible, it seems very necessary to adopt some plan for meeting the cost of water-main extensions which will be attractive to prospective builders.

Mr. Carleton E. Davis.* Mr. President, I am not going into the theory of the assessment for benefits, but I can perhaps give some practical experience on the question.

Benjamin Franklin is supposed to have established the assessment charge that prevails in Philadelphia. We are working now under an ordinance that was passed in 1855, and before that time the same principle was in vogue and is generally attributed to Benjamin Franklin when he established the water works.

We charge a dollar a front foot on each side of the street. The corner lots, after having paid a frontal charge, are charged only 50 cents on the side. No property extending to a rear street is charged on the rear street unless the property has a greater depth than 100 ft. The assessment is a lien on the property, and is collectible by the usual methods followed in such cases. If, however, a water pipe is necessary in a rural or country district and we have to go past unoccupied territory, where there is no immediate demand for development, in order to supply water for distant places, the intermediate land that is not developed is not subject to the lien, but no buildings put up in the future on such property can secure water until they have paid the $1 a front foot. In a suburban property, neither city nor country, it is left to the discretion of the bureau as to whether the frontage charge is or is not equitable, or whether it should be postponed.

In certain cases we are without ready money to lay water pipe, and in order not to arrest development we have an arrangement whereby the majority of the owners can lay a pipe under private contract. They do the actual work, subject of course to our inspection. In that case they are required to file with us a certified statement of the actual cost of the work. Each abutting owner then is prorated on that expense, but a property that does not join in the cost cannot have an attachment for a period of ten years unless they have paid their pro-rata share. After ten years the rights of the parties laying the pipe lapse and then the Bureau collects the full price of $1.

Mr. Baker referred to the prohibition amendment as affecting water revenue. Philadelphia has been looking after additional

* Chief of Bureau of Water, Philadelphia, Pa.

revenue to take the place of the supposed loss from that source. The water bureau suggested the possibility of a special assessment for the high-pressure fire service. It was not taken up, and perhaps it was not made very seriously. But the fact was brought out that the high-pressure fire service had given preferential fire protection, possibly affecting insurance rates, in certain districts of the city. It was questionable whether that additional protection had been reflected in the tax rate. The proposition was made of a tax per cubic foot of area of buildings within the zone of the action of the high-pressure fire system. I have forgotten what that rate on a cubic-foot basis was, but it was a very small yearly sum.

MR. A. R. HATHAWAY.* Mr. President, we in Springfield would not want the impression to go out — at least I would not, and I do not think Mr. Martin would — that we have been lax on this subject. It has been a problem, and is now.

Of course, in making main-pipe extensions in streets, there are two classes of streets, — the private street where a right of way and control is first obtained, and the public street. Then there are two primary reasons for making such extensions. In one case the municipal water works — (I do not call it the water *department*) — usually makes the extensions without petition or guarantee, to cover fire needs and the needs beyond the domestic uses. The other case is where real estate promoters start in to build up a tract or individual lot owners want water. In such cases they have to come in the office and get a guarantee-petition blank and have the same properly signed. We have our guarantees on practically the same basis as Mr. Saville spoke of. For a good many years they have been made on a basis of 10 per cent. of the cost of a 6-in. pipe, the 6-in. being the smallest we laid. Eight inches is probably the smallest we now lay except in certain cases, the same as in Hartford. We figured it out a good many years ago at about 15 cents a foot per linear foot of pipe wanted, and anybody coming into the office and wanting to get a pipe in a street was given a guarantee which he signed. One party or any number of parties could sign and distribute the amounts that they

* Water Registrar, Springfield, Mass.

guaranteed among themselves as they chose. But the aggregate of the guarantee must equal the above 10 per cent. of estimated cost for laying the pipe. Then, before the Board of Water Commissioners authorized the extension, we scanned the signers very closely, as it became a personal agreement and not a lien on the property; it could not be transferred from one person to another; the signers were held personally liable. After we accepted it and filed it away, the extension was made and the services were put in as property developed. People might buy lots, build houses and have them connected to the extension whether they were signers of the guarantee or not. But the water rents were all credited to that guarantee, and the balance between the rents received and the 10 per cent. total was laid on the signers at the close of each year. For a good many years we have been very successful in that method.

There is one thing we have not liked about it. The guarantee was perpetual and in some instances lasted too long. The signers were held to that guarantee until the water rental equaled the total amount of the guarantee, at which time the agreement automatically canceled itself. Sometimes it leaves out the owner of one lot or several lots who want to lay back and let the others take the initiative and develop the value of the property for him. That is the weak point. We have had a number of people of that kind, and they have not been in very good odor with the rest of the people on the street, but as fast as they sold out and the new owners became water takers, they would help the signers so much. Some method whereby each lot owner, benefited by such an extension, could be made to pay his proper share, would be desirable, but without some municipal ordinance or legislative enactment we could not do it very well.

Of late years, as we all know, there has been a growing laxness on the part of a certain class of foreign property owners, and after figuring the guarantees for the year and making up the balances and sending out the bills to the signers, we find that some of them have skipped out, become bankrupt, or something has happened to them, and we have to turn their balances over to the law department for collection. Our losses have been very small, however. I have had some tabulations made recently, to

show how we have been coming out with our main-pipe guarantees, and I thought the results might be of interest to you to-day. The first guarantee that was issued was made in 1892, and the total number of guarantees issued from 1892 to 1917, twenty-five years, was 485. The total number of guarantees canceled and filed away was 398, leaving 87 not yet canceled. Of the 398 which were canceled, 384 were canceled in the first five years of the life of the guarantee, or 79 per cent. of the total number issued. We consider this a very good showing. In the last five years, 1913 to 1917, (the tabulation being made only up to 1918), 158 guarantees were issued, of which number 90, or 56 per cent., have been canceled. A majority of the 87 uncanceled ones have been running but a few years, with a good prospect of being canceled by the increasing water revenue to their credit from such extensions.

Some of the others, running back in previous years, are within a year or two of their last bills for balances due, while a few of the older ones are considered as "hard nuts" and probably worthless.

We have lately decided that, instead of letting the real estate promoters and petitioners take the blank petitions out, we are going to have them come to the office and bring the signers to the office. We wish to be very sure that they personally understand the guarantee that they are signing. We have one case in particular where a party was a selectman of a town, and the town wanted to get an extension to supply hydrant purposes. And he went around and got some working people to sign the guarantee petition; and while they have taken the water as they agreed, the guarantee has not canceled itself, and they have been protesting against the assessment of the balance that is due, saying that they did not understand it, — that all they were to pay was the water rent. This man did not explain the guarantee to them as we would have done in the office. By insisting upon these guarantees being signed at the office, we will be sure that they understand it and that they are personally responsible before we put the guarantee up to the water board.

Another change we are considering is a guarantee limit, and I like Mr. Saville's idea of a ten-year term. Perhaps we might

put the percentage a little bit higher to start with or compute the annual amount of guarantee on a basis which will provide for the payment within a given term of years of a reasonable portion of the full cost of the extension wanted.

In certain cases where property does not develop as anticipated, and where, by means of sale or change, the particular interest of the guarantee-signers in such property ceases, it seems a hardship to continue to hold such signers to their guarantee-obligations after a reasonable number of years have elapsed.

MR. LEONARD METCALF.* Perhaps I can broaden the discussion a little, though I do not know that I have very much to add.

Mr. Davis just suggested to me the increasing difficulty which a large city would have with a great number of such accounts. In Philadelphia, he tells me, he has about 10 000 new accounts a year. You can see that the difficulty of keeping track of any such volume of agreements or contracts, extending over a period of ten or twenty years, would multiply very rapidly. In a small community it is not so burdensome.

You may be interested in the experience which we have had in my home town of Concord, where, when we built the sewer system, Mr. William Wheeler, who is a member of this Association, and who was for a great many years chairman of the water board and subsequently the sewer board, worked out a scheme under which the income from the water works has carried the interest and sinking-fund account on the sewers. The water-works earnings contribute about $11 000 a year to the sewer fund, and have liquidated about one third of the sewer debt.

It is interesting to note that we have had no litigation, which is rather unusual where some form of betterment tax is levied. To make the charge equitable there is remitted one fourth of the water charge in those houses which cannot be served also by the sewers, so that the houses that have only one service pay smaller water rates.

I was very much surprised, some time ago, when Mr. Frank C. Jordan, secretary of a committee of the American Water Works Association, and secretary of the Indianapolis Water Company,

* Metcalf & Eddy, Boston, Mass.

investigated the question of rates in different states, to see how many states there were in the country that already had the system of charging a frontage tax. It is my impression that there were something over 30 cities, and the amounts varied in different places, but usually they were determined by the approximate cost of a 6-in. or 8-in. pipe on a frontage tax regardless of the size of the pipe which was put in.

That, for instance, is the case at Los Angeles, where, if I remember rightly, 80 cents a front foot is paid on each side of the street by abutting property, or $1.60 per linear foot of pipe, which nearly, if not quite, takes care of the distribution pipe system cost. I remember that Mr. Hazen and I figured roughly that the water rates in Los Angeles would nearly have to be doubled if that proportion of the cost of the works were not borne by the abuttors directly, through this front-foot charge. Obviously, in passing, it is to be noticed that when you compare rates of cities, you must be careful about any such tax as this, because it has a material effect on the rates.

In reference to articles upon the subject, it occurs to me to call to your attention an article which was presented by Mr. J. B. Lippincott of Los Angeles before the American Society of Civil Engineers,* perhaps two years ago; and I think that Mr. J. L. Van Ornum also presented a paper before the American Society of Civil Engineers † some fifteen years ago, in which this general question of betterment taxes was thoroughly discussed. Both articles were good.

I was particularly impressed in our western cities, and in some of the middle western cities, with the advantage to the water department and to the city, of having some such tax as the front-foot-tax, on the basis of 6-in. or 8-in. pipe, because of the tremendous area included within city limits in many of our western cities. There is a marked difference in that respect between our eastern and our western cities, and it has led to increasing the cost of the public utilities to the residents of a city tremendously. You may take as an example of this the city of Denver, which is

* Trans. Am. Soc. Civil Eng., Vol. 81, p. 413.

† Trans. Am. Soc. Civil Eng., Vol. 38, p. 336.

built out in different directions with long stretches between the settled areas. It places a great burden on the city as a whole for its public service, its water pipes, gas pipes, electricity, and so on. A great part of the cost of those utilities would be saved if the city were more compactly built. Inasmuch as that is the result generally of land development or speculation schemes, it seems to me not unreasonable to throw some of the burden of that cost back again immediately on the land. I must confess that as I have reviewed the situation in some of our western cities more and more it has seemed to me that it was equitable to throw that burden on the land. It is true that there are cases in which unfairness would result; but that is true of any system that you can devise — there are exceptions to the rule. It is generally equitable to make those who benefit by the substantial increase in the value of the land through its conversion from country or grazing lands to suburban property, pay a portion of the burden of the utilities, rather than to throw that burden back again, upon the compactly settled city, which does not benefit directly by the development of those more remote areas.

The requiring of a guarantee, to which Mr. Saville has referred, is common practice. The percentage return exacted has varied very materially. In our own town, where we have for the most part a gravity system, a 4 per cent. basis has been used instead of 10 per cent. Of course, under those circumstances there is no return for the water, but the general system of carrying out the guarantee has been the same as that referred to here, and I do not think that it has been burdensome.

The practice of the commissions in this respect has varied materially. I was very much surprised a few years ago in appearing for the Milford Water Company, before the State Board of Health, which then had jurisdiction in water-company matters, at a ruling which was made by the board in regard to an extension desired in a section of the city where we showed that it could not possibly be commercially successful. The company had theretofore adhered to the general rule that unless a return of 10 per cent. upon the investment could be earned the extension would not be made. The board admitted that the return could not be earned, but took the position that if the citizens were willing

to bear the burden of additional payment for hydrants, or increase in rates, there was no reason why they should not have the extension. I called the attention of the Board to the fact that when you once departed from a rule of that sort it was exceedingly difficult to draw the line anywhere, and that there were other extensions in which the abuse would be greater; but the board adhered to its decision. The extension was made, and the return proved totally inadequate as predicted, and is a burden, therefore, upon the remainder of the community. Since then an additional extension has been asked for and has been a matter of embarrassment. I think that from a business point of view the course adopted was exceedingly unfortunate.

A similar situation arose, I remember, in the administration of the Indianapolis Water Company a few years ago, when complaint was made to the Public Service Commission by some of the real estate interests that the company would not make extensions except under a stated return. I think the return was less than 10 per cent. but it may have been 8 per cent. at that time. The water company said to the commissioners that if they wished to decide this issue they were entirely content to be relieved of the burden of it, because it was a very unpleasant duty. They asked first, however, to take the commission out on to the ground and show the commissioners the character of the development that was proposed and the business aspect of the matter. The commission undertook for a time to pass upon the question, and as I remember, within a few months, certainly within the year, threw it back on the company with the comment that it preferred the company should make the decision. In other words, I think that the political aspect of the matter sank in a little and that the commission realized that it was not a popular thing to have to deny these extensions, and when the commission faced the practical situation it very soon realized the truth of the water company's statement, that as a business proposition it could not be done unless the additional burden were thrown upon the rest of the city.

I remember another case, — that of San Antonio, Texas, — in which the policy, referred to here, was adopted, of permitting the real estate men to lay their own wrought-iron pipe systems

without giving any fire-protection service, and the water company simply connected up with those pipes and collected the revenue for the water which was distributed. That resulted finally in their having a very large amount of small pipe in the outskirts of the city. I state this with some reservation, as it is some time since I went over those figures, but it is my recollection that there were over a hundred miles of that wrought-iron pipe, and that when we came to discuss with the city authorities the renewal of the hydrant contract, one of the provisions of the agreement looked toward the gradual replacement of this large amount of wrought-iron pipe by cast-iron pipe. The laying of the wrought-iron pipe in many cases was distinctly advantageous financially, in that a return was enjoyed for a considerable period of years on a small investment, because there the pipes were laid very shallow, and the laying of the cast-iron pipe could be deferred until the revenue was sufficient to carry the added investment of the cast-iron pipe system, — particularly in view of the fact that the real estate had borne the burden of the wrought-iron pipe system as originally installed.

I think that the figure that Mr. Saville quoted in regard to the percentage of return suggested by Mr. Ledoux of 25 per cent. is a high one. More often a return of 10 per cent., in some cases a return of 12 or 15 per cent., has been exacted; but not often so high as 25 per cent.; although it is obvious that a return of 10 per cent. will usually not leave much if any margin over the cost of the water.

Mr. A. R. Hathaway. There comes to my mind certain recent opinions handed down by some of the public utility commissions in some of the western states. I have three cases in mind where they have stated that there is a question in their minds whether a water works, privately or municipally owned and operated, can reasonably refuse an extension of mains simply because the proper percentage of return on the cost basis is not met by the water takers or by responsible signers. In other words, they state that the water works should serve the public, and should put in such extension whether it is to be a paying proposition or not. That seems to me to be quite a drastic ruling.

MR. A. E. MARTIN.* Mr. President, I do not want the members of this Association to go home carrying the idea that there is any resident of Springfield who would feel any chagrin over getting his neighbors to sign a guarantee for water rental that would benefit him. But there is only one man in Springfield that I can remember at this time who ever refused to help out his neighbors by signing a guarantee. Mr. Hathaway has given you the particulars of our method there very much more minutely than I could if I had gotten on my feet before he did. But, in this particular that Mr. Saville refers to, I think he must have misunderstood me over the telephone, as our conversation was carried on in that way. This man to whom I referred is one who, instead of feeling any chagrin over accomplishing such an object as he evidently did, and — as I *know* that he did, (for he had houses on the line and came in afterward and had them connected and was able to get water from a pipe, the income from which was guaranteed by his neighbors), — instead of feeling any chagrin, as I say, he is a man who would smile to himself in a self-satisfied, sardonic way. Evidently he feels that way, for he has allowed, in more than one instance, his neighbor to help him out in such cases, and I know he feels no chagrin about it.

MR. GEORGE A. KING.† Mr. President, one point Mr. Hathaway made which I think might be qualified. As I understand, he stated that in case the land was sold by the man making the guarantee, that the guarantee could not be collected. If that party had built a house upon the property and then sold the property, I think the guarantee can be collected. We have had a decision to that effect from the city solicitor, claiming that special privileges might command special rates from the water commissioners.

In getting our guarantees we get a separate paper from each guarantor, and he guarantees a certain amount. We do not get one paper in which all join together in one guarantee for the whole; each one is a separate guarantee.

MR. SAVILLE. I would like to ask Mr. Metcalf if those houses served by the small pipes could not, instead of the department

* Superintendent of Water Works, Springfield, Mass.
† Superintendent of Water Works, Taunton, Mass.

taking them over, have been as well supplied if at the end of the city's main a master meter had been placed and the water billed to the man owning the small pipe, rather than putting the burden of the small pipe on to the city department.

Mr. Metcalf. If you are referring, Mr. Saville, to the San Antonio situation, it is my recollection that the water company did not take over the burden of the water system at all; it simply undertook to supply the water. But it had the machinery for the collecting of the bills, and it got its compensation directly from the people who used the water. But it paid nothing for the pipes, and it disconnected those pipes and left them in the ground and laid cast-iron pipes at a later date.

Mr. Saville. In the place of them?

Mr. Metcalf. In the place of them, when it finally got to the point of wanting to put in a larger pipe system giving fire-protection service.

Mr. Saville. Mr. Hathaway raised the question whether there was an obligation or not on water departments to supply certain portions of a city. I think that one answer to that is that there may not be an obligation from the fact that the maintenance and operation charges of the water department are not met from the tax levy but from the income from the water department itself. If they were met from the tax levy it seems to me as though there might be such an obligation. I don't know whether that is sound law or not, but it seems to me as though that might be so.

Mr. Patrick Gear.* Mr. President, if we had the same rule in Holyoke that Mr. Davis has in Philadelphia it would be a golden rule and would be all right; then we would not have any trouble collecting our water taxes. But where you have been liberal for a number of years, running a thousand feet of water pipe here and there in all parts of the city without any charge, and selling the water at a very low rate, then I say you would have a very hard time trying to raise your water rates.

In looking around to see where we could get some money, we decided to assess the property owners for new extensions on the

* Superintendent of Water Works, Holyoke, Mass.

$1.00 per front foot basis, which I thought at the time was a little high. But I never dreamed that Mr. Davis was charging the same as we are. Before this rule went into effect a man built a house on a street fifty feet beyond the end of pipe laid and we extended the main as far as his house free of charge. After this rule was in vogue along comes another man and builds a house on the same street fifty feet east from end of pipe laid and we extended the main as far as his house, charging him $50.

There is another proposition before our board, which is a large one, and that is, where pipes are laid on streets for a number of years — where a man builds a house and applies for a water connection, that he will pay an assessment for same before the water is turned on to his premises. But I can readily see from what is said here this afternoon that it is a larger proposition than I figured it to be. Nevertheless, I think it will do away with a great deal of bookkeeping. I can't say whether it is a good idea or not, to make a service charge for every service connection that is put in hereafter.

We have over twelve hundred vacant lots in our city, and the main pipes have been put in for years and years. Now the owners of these said lots, under our present system, would get away without paying anything in case a service connection was made — but a fellow that is going to build on a new tract where the main will have to be extended must pay for extension and also the service connection. I am of the opinion that we can put a charge on all owners of said vacant lots and future extensions and thereby do away with the front-foot charge.

Mr. Metcalf. It might be interesting to ask Mr. Gear if, inasmuch as they are in need of revenue and want to be fair to everybody, it would not be a good scheme to put that service charge on all the houses where they have a service now.

Mr. Gear. Well, Mr. President, with those service charges, and also other things, we have found that money could be gotten without charging the poor man. For example, early last year we increased our revenue without charging any poor man a cent. There was only one automobile fellow who did not want to pay, but he paid it just the same.

Mr. John C. Chase. One interesting thing in connection with

Mr. Gear's remarks was in regards to the bookkeeping. He says they have no trouble in knowing where the money goes to.

Mr. Gear. No extra bookkeeping, I think I said. Our present clerks will do all the work required. We have hopes of getting this new system started without any extra clerks.

Mr. Fred L. Cushing.* Mr. President, we have in our rules and regulations a provision which explains why we charge the 6 per cent. We charge 6 per cent. for an extension and require a guarantee by the person wanting the water, and a bond that they fulfill the guarantee for a term of thirty years, which will pay 3½ per cent. interest and 2½ per cent. sinking fund, making 6 per cent., the city acting on the theory that they advance the cost of the work and get it back in their ordinary charges. We have a good deal the same troubles that the others do, and I do not think that is the best method. If we could have it made a lien on the property, we would make all the property that was benefited pay the expense, but as we can't even make the water rates a lien on the property we don't see much use in trying to make the construction charge.

Mr. Frederic P. Stearns.† Mr. President, in discussing this subject I will have to hark back to the time when I was with the State Board of Health, some thirty years ago. At that time I was a good deal interested in a comparison between the methods of raising money for sewerage systems and for water works. I am referring now mainly to the original systems, rather than to extensions.

In cases where sewerage systems were to be built, it was the usual rule to assess the cost of the system, or of a large part of it, upon the owners of property bounding on the streets in which the sewers were laid. This required large payments by the owners, and often was so great a burden upon them as to create opposition to the installation of a system and prevent its construction. The establishment of a very much needed sewerage system was in this way deferred. In any case, under this arrangement the town assumed the responsibility for the annual cost of operation and

* Water Registrar, Medford, Mass.
† Consulting Engineer, Boston, Mass.

maintenance, and generally the interest and sinking fund charges on a part of the system.

Municipal water works, on the other hand, were generally built by the issue of bonds, no charge being made against property except an indirect charge for hydrant service, and an annual assessment was made upon the water takers to defray the expense. This method was very successful, as nearly all the municipal water works in Massachusetts were receiving revenue sufficient to pay the running cost, the interest on the bonds, and a very considerable amount for sinking the bonds. As a general rule, the amount paid into the sinking fund was much in excess of the actual depreciation, so that the net debt was less than the actual value of the works. In other words, this method was one which did not delay a needed municipal enterprise, and did not cause the people to kick nearly as much at the annual water rates as they did at the large sewer assessments.

As showing the excellent financial condition of the water works under this system of raising money, I recall a study which I made as a part of an investigation for a Metropolitan water supply in 1894. The cities and towns in the Metropolitan District within about ten miles of Boston spent for extensions of works during the ten years from 1883 to 1893 about $13 000 000, and the net debt of these places in the same time increased only $2 000 000. That is to say, the revenue from water rates had been sufficient during these years to pay by far the greater part of the cost of extensions. This is an example of the large amount of money which can be raised through annual assessments without being especially burdensome.

I do not wish to argue against the justice of assessing costs upon property benefited, but under the conditions existing in New England that is not the practical way to obtain the best results, because money can be acquired much more easily and in greater quantity through annual assessments than from large special assessments. Even in the matter of extensions, I believe that a liberal policy should be employed. It does not do any serious injustice if a small part of the revenue obtained from the existing water takers is applied to extensions so as to prevent too large a charge against those benefited by the extensions.

Mr. X. H. Goodnough.* Mr. Baker's suggestion is a most interesting one. One of the serious difficulties encountered by health departments at the present time is that of securing extensions of water-works systems in sparsely settled districts. The public water supply is by far the most important of all public services in its relation to public health and is also one of the most important of all in its relation to public comfort and convenience; but it is the common practice when a petitioner desires the extension of a water main in a sparsely settled district to charge the whole interest on the cost of laying the main to the person who asks for the water and, unless he can give a suitable guarantee, the work is not carried out. Of course, when such extensions are made, if other takers come in along the line of pipe they are supplied with water generally at the usual rates, and while the charge to the original petitioner is reduced he still may pay a disproportionate share of the cost. Very often along such extensions there are dwelling houses where the owners choose to continue the use of their own private water supplies and decline to take water from the public works, and while their estates are improved they pay nothing for the added value.

This plan of charging for a water main seems unfair and unreasonable. Under its operation it is sometimes impracticable to secure the extension of the public water supply into districts supplied from polluted local sources, which may constitute a serious menace to the public health, except in cases where some private individual pays the larger part of the bill. Even in such cases, most of the inhabitants would willingly become water takers provided they could obtain their supplies at the same rates as other citizens of the town, but cannot afford to pay the whole charge for an extension until such time as enough takers come in to reduce the charge to the regular rate.

One of the improvements following the introduction of water supplies in towns and villages noted many years ago was the decrease in the prevalence of typhoid fever in such communities, and there are still small villages and districts dependent for water supply on private wells in which a relatively high rate of typhoid

* Director and Chief Engineer, Mass. State Dept. Health.

fever still persists. Experience has shown that many of the private wells and other supplies used in villages and rural districts are polluted, and much of the typhoid fever occurring in the late summer and early autumn may still be due to this condition. For example, one small town in Massachusetts, used to a considerable extent as a summer resort and still supplied with private-well waters, has had a persistently high typhoid rate for many years. A thorough examination of all the facts has failed to show any other cause for the prevalence of typhoid in this town than the polluted wells.

Many cases have arisen in which it has been found important for a city or town to extend its water-supply system to a sparsely settled district for the protection of the public health, and in such cases a part at least of the cost of the extension might reasonably be charged to the town as a health measure. A benefit also accrues usually in respect of charges for insurance following the introduction of a water supply of sufficient capacity for fire service. Furthermore, the laying of a water main in such a district unquestionably enhances in most cases the value of the property. It would seem reasonable not only that the town should pay a part of the cost of such extensions as a health measure, but also that a considerable part of it should be assessed upon the estates benefited in proportion to the benefit which they receive.

It does not seem fair or reasonable to operate public water supply in any city or town solely as a business proposition and as a means of protection from fire. The water supply is, in addition, a most important means of protection of the public health, and its use for that purpose should be given due consideration. If a sewer is a benefit in any street, and if when a sewer is laid it is reasonable to tax all the abutters whose lands can be drained into the sewer, it is unquestionably even more reasonable that when a water supply is laid in a street the abutting owners should also pay a proportion of the cost of the improvement.

This consideration would apply not only in municipalities where the works are owned by the public, but also in municipalities supplied by private companies.

In states where the regulation of the service of water companies

is wholly in the hands of the state health department, it is practicable for that department, on the ground of public health, to require an extension of the water service to a sparsely settled part of a town where the public health requires such extension, but of course in such cases the remaining water takers must pay for a part of the cost of such improvement where the number of water takers and fire hydrants does not supply a sufficient return on the cost. In states in which the water-works regulation is in the hands of a public-service board, it would probably be impracticable for such a board to act as a board of health, but this difficulty might be removed by suitable legislation.

There are other considerations which affect the extension of water mains in sparsely settled districts, especially the question of the use of the public water supply for irrigation in densely populated regions like Massachusetts. There is no doubt that means for irrigation are almost as necessary in the east as in the west, since extreme droughts for short periods often occur in the eastern states which result in the ruin of the year's crops, a condition which could be avoided if irrigation were available. If agriculture is to be restored in New England, means for irrigation will have to be provided. While in many places it is not difficult for each farmer to provide his own irrigation system, there is no doubt that it can be provided at much smaller expense from public works. Water from public water-supply systems is already used to a very considerable extent in Massachusetts for irrigation on farms where the public water-supply pipes are available for such use. In fact, some of the public water supplies in the Connecticut Valley were introduced largely for the purpose of the irrigation of tobacco and onions in the early part of the year when crops are sometimes lost if a drought occurs. If the water-supply systems are to be used generally for irrigation, as will very probably be the case, the laying of the pipes in the beginning at least will involve a large expense which payment for the water used will in many cases fail to meet, since in Massachusetts the quantity of water required for irrigation would rarely be great, excepting in very dry years. With a provision for the assessment of a part at least of the cost of such works upon the municipality for the protection of the public health, where such protection is afforded,

and a part upon the estates benefited, the cost of extensions of water-supply systems need not fall wholly upon the individual who has the enterprise to introduce the water or upon the remaining water takers. It can be made to fall in many cases in part upon the municipality for the protection of health, and probably in large part upon all properties benefited by such extension.

PROCEEDINGS.

MARCH MEETING.

HOTEL BRUNSWICK,
BOSTON, MASS., March 12, 1919.

The President, Mr. Samuel E. Killam, in the chair.

The following members and guests were present:

HONORARY MEMBERS.

E. C. Brooks.
R. C. P. Coggeshall.
F. E. Hall.
F. P. Stearns.
R. J. Thomas. — 5.

MEMBERS.

E. R. B. Allardice.
M. N. Baker.
L. M. Bancroft.
J. F. Barrett.
G. W. Batchelder.
C. S. Beaudry.
F. D. Berry.
A. E. Blackmer.
George Bowers.
G. A. Carpenter.
H. H. Chase.
J. C. Chase.
F. L. Cole.
John Cullen.
F. L. Cushing.
C. E. Davis.
John Doyle.
E. D. Eldredge.
Frank Emerson.
W. E. Foss.
Patrick Gear.
H. T. Gidley.
F. J. Gifford.
H. J. Goodale.
R. A. Hale.
A. R. Hathaway.
D. A. Henderson.
C. R. Hildred.
J. L. Howard.
W. F. Howland.
J. A. Hoy.
J. W. Kay.
Willard Kent.
S. E. Killam.
G. A. King.
H. V. Macksey.
A. E. Martin.
J. H. Mendell.
F. E. Merrill.
G. F. Merrill.
Leonard Metcalf.
M. L. Miller.
William Naylor.
W. H. O'Brien.
T. A. Peirce.
H. E. Perry.
E. W. Quinn.
L. C. Robinson.
H. F. Salmonde.
P. R. Sanders.
C. M. Saville.
A. L. Sawyer.
C. W. Sherman.
Channing Smith.
J. Waldo Smith.
Sidney Smith.
J. F. Sullivan.
S. H. Taylor.
E. J. Titcomb.
D. N. Tower.
R. S. Weston.
H. T. Wheelock.
G. E. Winslow.
C. L. Wooding. — 64.

ASSOCIATES.

Bond, Harold L., Co., by F. M. Bates.
Builders Iron Foundry, by A. B. Coulters.
Byers, A. M., by H. F. Fiske.
Donaldson Iron Co., by C. F. Glavin.
Eddy Valve Co., by H. R. Prescott.
Fire and Water Engineering, by C. B. Hayward.
Hayes Pump Machinery Co., by F. H. Hayes.
Hersey Mfg. Co., by J. Herman Smith.
Lead-Lined Iron Pipe Co., by T. E. Dwyer.
Mueller, H., Mfg. Co., by C. J. G. Haas.
National Meter Co., by J. G. Lufkin and H. L. Weston.
Neptune Meter Co., by W. H. McGarry, Jr.
Pittsburgh Meter Co., by G. C. Northrop.
Rensselaer Valve Co., by C. R. Brown and I. A. Rowe.
Smith, A. P., Mfg. Co., by F. L. Northrop.
Thomson Meter Co., by E. M. Shedd.
Union Water Meter Co., by H. W. Jacobs.
United Brass Mfg. Co., by G. A. Caldwell.
Warren Foundry and Machine Co., by H. H. Kinsey.
Wood, R. D., & Co., by H. M. Simons.
Worthington Pump and Machinery Corp., by Samuel Harrison and E. P. Howard. — 21.

GUESTS.

MASSACHUSETTS

Billerica, G. A. Stowers.
Somerville, F. M. Hutchinson.
Swampscott, John Albee.

RHODE ISLAND.

Bristol, J. M. Jones.

NEW YORK.

Woodhaven, James Cochran. — 5.

The Secretary presented applications for active membership, properly endorsed and recommended by the Executive Committee, from William Colquhoun, Yonkers, N. Y., superintendent Water Bureau; Charles B. Garmon, Lowell, Mass., resident engineer of general construction work and engineer in charge of fire protection and water-works system of Proprietors of Locks and Canals on Merrimack River; Stephen H. Taylor, New Bedford, Mass., assistant superintendent New Bedford Water Works; Charles L. Wooding, Bristol, Conn., chairman of water commissioners; Morrison Merrill, Wakefield, Mass., superintendent

water and sewer department; A. J. Mylrea, Toronto, Ont., special risk engineer.

On motion of Mr. Lewis M. Bancroft, the Secretary was directed to cast the ballot of the Association in favor of the applicants named, and he having done so they were declared duly elected members of the Association.

President Killam. I am pleased to announce that the annual convention will be held in Albany, N. Y., probably the second week in September. [*Applause.*]

Mr. William E. Foss, chief engineer, Metropolitan Water Works, Clinton, Mass., read a paper, illustrated with stereopticon, entitled, "Brief Description of Break in 1 200 H.P. Turbine, Wachusett Power Plant, Metropolitan Water Works." Messrs. Carleton E. Davis, F. H. Hayes, Robert S. Weston, Richard A. Hale, and Percy R. Sanders took part in the discussion.

Mr. M. N. Baker, associate editor, *Engineering News-Record*, New York, read a paper on "Meeting Water-Main Costs by Assessments for Benefits." The discussion was led by Mr. Caleb M. Saville and participated in by Messrs. Carleton E. Davis, A. R. Hathaway, Leonard Metcalf, A. E. Martin, Geo. A. King, Patrick Gear, John C. Chase, Fred L. Cushing, and Frederic P. Stearns.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, March 12, 1919, at 11 o'clock A.M.

Present: Samuel E. Killam, President; Henry V. Macksey, Charles W. Sherman, Percy R. Sanders, James H. Mendell, Frank J. Gifford, A. R. Hathaway, Patrick Gear, Lewis M. Bancroft, and Willard Kent.

Five applications for membership were received, viz.: A. R. G. Booth, assistant chemist, Massachusetts State Board of Health, Boston, Mass.; George M. Graffan, auditor, Portland Water District, Portland, Me.; W. W. Nye, trustee Kennebec Water District, Waterville, Me.; A. B. Thompson, assistant superintendent, Kennebec Water District, Waterville, Me.; and one application for reinstatement to membership, viz.: Thomas J. Carmody, water commissioner, Holyoke, Mass.

On motion of Mr. Sanders, seconded by Mr. Gifford, it was voted: That the President represent the Association at the Tenth Annual Joint Dinner of the Boston Section of the American Society of Mechanical Engineers, the Boston Section of the American Institute of Electrical Engineers, and the Boston Society of Civil Engineers, at the Boston City Club on the evening of April 2, 1919.

Voted: That the President be and hereby is authorized to appoint a delegate to meet with the National Service Committee on Engineering Council in joint session at Chicago, Ill., April 23 to 25, 1919.

Messrs. A. R. Hathaway and Patrick Gear, the Committee to investigate and report on a place for holding the next Annual Convention of the Association, presented their report and, after discussion — on motion of Mr. Gifford, seconded by Mr. Macksey — it was unanimously voted: That a four days' convention be held at Albany, N. Y., in September next and the President is hereby authorized to appoint a Committee of Arrangements with full powers.

Adjourned. Attest: WILLARD KENT, *Secretary.*

HARVEY M. GEER.

The death of Harvey M. Geer, a member of the New England Water Works Association since October 10, 1897, occurred on March 18, at Troy, N. Y.

The following is quoted from a local paper:

Harvey Mosher Geer, of Ballston, a native Trojan, died at the Samaritan Hospital in this city yesterday. Mr. Geer was born in Troy, February 22, 1851, and was a son of the late Gilbert Geer, Jr., and Frances A. Mosher. He graduated from the Troy high school and the Rensselaer Polytechnic Institute, class of 1872, with degree of civil engineer, and was a member of the Zeta Psi college fraternity.

Mr. Geer was engaged as engineer on the construction of the original Congress Street bridge and built the Third Street bridge under contract with the city of Troy; also the water-supply systems for Johnstown, N. Y., and Fairhaven, Vt., and additions to the water-supply system of Amsterdam, N. Y. He was engaged on water-supply systems for Macon, Ga., and Westboro, Mass. For many years Mr. Geer was engaged in the manufacture of news print at Ballston Spa, with the late Harvey Donaldson of that place, under the name of Donaldson & Geer. Of late years Mr. Geer had been a consulting engineer, with offices in Ballston Spa, and was engaged in the development of hydro-electric projects, water-supply and sewage-disposal systems, and in expert court work. His last work, immediately previous to his death, was on a hydro-electric development for the American Manufacturing Company at Mechanicville, N. Y.

Mr. Geer had been a member for many years of the American Society of Civil Engineers and New England Water Works Association. He married Caroline Akin of Johnstown, N. Y., and is survived by her, a daughter, Helena Geer, and a son, Howard E. Geer, all of whom reside in New York.

RUFUS MASON WHITTET.

Rufus Mason Whittet, son of Alexander and Isabella (Proudfoot) Whittet, was born October 17, 1878, in Lowell, Mass., and died at Boston, Mass., on December 10, 1918. He came of

Scotch ancestry, being a lineal descendant of James Whittet, of Kintillo, Scotland.

He was educated in the Lowell public schools, having graduated from the Moody Grammar School in 1893 and from the Lowell High School in 1897, at the age of nineteen. Deeming it wise to

further continue his academic studies, he returned the following year to the Lowell High School, taking the post-graduate course.

Mr. Whittet then passed the entrance examinations for both Harvard College and the Massachusetts Institute of Technology. Deciding in favor of Technology, he entered that institution in 1898 and graduated in June, 1902, with the degree of bachelor of science in the department of Sanitary Engineering, presenting as his thesis, "A Study of the Stream-Flow Records of the United States Geological Survey."

Upon his graduation from the Massachusetts Institute of Technology, Mr. Whittet joined the engineering staff of the State Board of Health, and in the wide field of work covered by that department he found employment congenial to his tastes. Taking a deep interest in its work, he soon became a most valued member of its staff and was the principal assistant engineer of the department at the time of his death.

He was a civil engineer who believed in the elevation and dignity of his profession, and he acted on this belief with a fine enthusiasm. His principal characteristics — clear thinking and sound judgment — were combined with great executive ability, and his early death ended a career begun with great promise.

Mr. Whittet was a member of the American Society of Civil Engineers, the Boston Society of Civil Engineers, the New England Water Works Association, and a prominent member of the Masonic Fraternity.

He was married in September, 1916, to Effie Osgood Byron, of Jamaica Plain, Mass., who, with a daughter, Helen Isabella, born January 16, 1918, survives him.

In appreciation of his service to the state, the State Department of Health adopted the following tribute to his memory:

"Rufus Mason Whittet, C. E., principal assistant engineer of this department, died on December 10, 1918, a victim of the prevailing influenza epidemic.

"Mr. Whittet joined the engineering staff of the State Board of Health upon his graduation from the Massachusetts Institute of Technology in 1902, and has been the principal assistant engineer of the department since 1908.

"His energy, thoroughness, clear thinking, and sound judgment, were of invaluable assistance in the studies of water supply and

drainage and the great variety of kindred problems embraced in the work of the department, while his quiet manner, his fairness and his kindness made work with him a pleasure. These qualities, with a high sense of honor and loyalty to his associates, made him respected by all and loved by a wide circle of friends."

T. P. MARTIN.

Died August 11, 1918. Superintendent Water Works, West Springfield, Mass. Member of New England Water Works Association since September 9, 1914.

Volume 33. SEPTEMBER, 1919. $3.00 a Year.
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OF THE

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OF THE

New England Water Works Association.

1919.

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A. R. HATHAWAY, Water Registrar, Springfield, Mass.
PATRICK GEAR, Supt. Water Works, Holyoke, Mass.

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GEORGE A. CARPENTER, City Engineer, Pawtucket, R. I.
EDWIN L. PRIDE, Public Accountant, Boston, Mass.
FRANK A. MARSTON, Designing Engineer, Metcalf & Eddy, Boston, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 900 men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXXIII. September, 1919. No. 3.

THE NEW TEN-MILLION-GALLON RESERVOIR OF THE CITY OF DAYTON, OHIO.

BY LEONARD METCALF AND WILLIAM T. BARNES.*

In the year 1917–1918 the Water Department of Dayton, Ohio, built a covered concrete masonry reservoir of 10 million gallons capacity. The population, then estimated at 148 000, — which had practically doubled in twenty years and increased by 38 per cent. in the last decade, — reflected growing war activities. The water consumption was 50 per cent. greater than ten years earlier and the rapidly increasing demand threatened to outstrip the available resources of the department, so that it was necessary to improve the plant, notwithstanding the abnormal prices then prevailing.

Though the average consumption was but 13 million gallons daily, the ordinary maximum daily rate of consumption was upwards of 18 million gallons, and the ordinary maximum hourly rate was equivalent to 30 million gallons daily. The ratio between the maximum and the minimum hourly fluctuations was approximately as 5 : 1, the minimum rate of consumption being about 6 million gallons per day.

The water supply is derived from a system of driven wells on the banks of the Mad River, in proximity to the industrial center of the city, and is pumped to the consumer under direct pressure, except in the high service district of the northwest, where there is a standpipe of 900 000 gal. capacity.

* Both of the firm of Metcalf & Eddy, Boston, Mass.

With such wide variations in rate of consumption and with no low service storage, the conditions were difficult to meet, for the entire maximum demand had to be supplied directly by the pumps and the wells, the normal capacity of which was less than the actual maximum rate of consumption during periods of more than one hour. This condition was further aggravated, during fires, by the fire-stream demand and the greater consumption, waste and leakage of water resulting from raising the pressure at such times. The effect upon consumption of this increase in pressure is interestingly shown in Table 1 and Fig. 1.

These conditions involved, in various ways, elements of hazard which it was not wise for the city to assume, particularly in view of its important war work. The possible direct loss from fire, and the indirect losses from interruption of service and in output and wages following a severe fire, were too serious to be incurred.

TABLE 1.

TEST OF RELATIVE WATER CONSUMPTION UNDER VARYING CONDITIONS.

Test made March 3, 1917, with DeLaval 20 M.g.d. unit in service.
Rate of consumption determined from Venturi Meter Chart.

Time Period. March 3, 1917, P.M.	Pump Pressure. Pounds.	Rate of Consumption in M.g.d.			
		During Period.	Change by Increasing or Decreasing Pressure.	Increase above Average Consumption with Pressure at 60 Lb. (Average = 12.6 M.g.d.).	
				M.g.d.	Per Cent.
3.15 to 3.40	60	13.1	.....	...	....
3.42 to 3.53	90	16.0*	+2.9 −3.2	3.4	27.0
3.54 to 4.05	60	12.8†	.....	...	....
4.06 to 4.12	80	14.75	+1.95 −2.15	2.15	17.0
4.12 to 4.22	60	12.6	.....	...	....
4.22 to 4.31	70	13.7	+1.1 −1.7	1.1	8.8
4.31 to 4.42	60	12.0	.....	...	....

* In first three minutes increased to 18.2 M.g.d.
† In first six minutes fluctuated between 11.5 and 12.8 M.g.d.

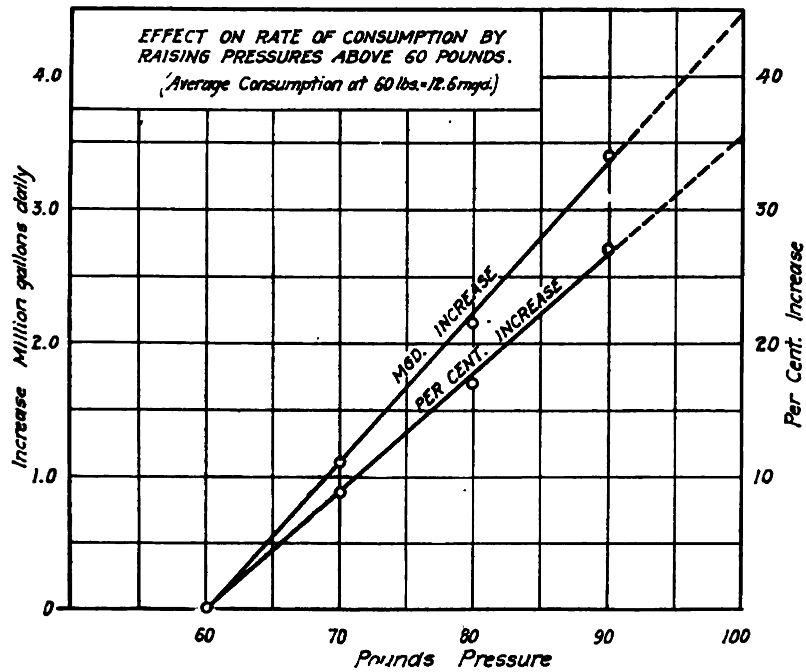


FIG. 1.

Influence of Topography upon Character of Water Works Plant. — The topography of Dayton lends itself admirably to the division of the water distribution system into two services, — high and low. The low service comprises the congested value district and surrounding business district of the city, upon the floor of the broad valley through which flows the Miami River and its main tributary, the Mad River, and into which discharge the Still-water River and Wolf Creek. Above the river plain, which lies at general elevation of 740 ft. (above mean sea level), and virtually surrounding the city, lie upland plains, the margins of which are generally between elevations 850 and 900, and which rise with increasing distance from the city, to an elevation of 1 000 ft., more or less. The upland plains furnish advantageous sites for reservoirs close to the heart of the city, from which water may

be delivered to the low service district at fair domestic pressure (70 lb. per sq. in., more or less) in ample volume for the maximum fire demand, without undue friction loss, and without involving burdensomely expensive pipe connections. The high service districts upon the hillsides and heights above can most advantageously be served from interconnected standpipes, to which water may be pumped from the centrally located main pumping station.

Consideration was given to the possibility of building a suction reservoir in proximity to the pumping station, and it seems likely that such will be built at a later date; but as the first step in the solution of the storage problem it was found more advantageous to locate the equalizing reservoir upon the upland plain. Later, additional reservoirs will be added upon the heights in different sections of the city, feeding their supplies into the common center, the heart of the city.

Function of the Reservoir. — The function of the reservoir is, of course, to furnish storage and equalize the rate of pumping so that, regardless of fluctuation in domestic and industrial consumption and of ordinary fire demand, water can be delivered into the distribution system in a way to develop the greatest safety and economy in the operation of the pumps. In view of the high cost of labor and building material, it was desirable that the changes involved should be kept at a minimum.

The significant rates of demand for water were found to be:

Year.	Population.	Slip. Per Cent.	Rate of Water Consumption.				
			Per Capita.	Average Day.	Maximum Day.	Maximum Week.	Maximum Hour.
			Gal. per Day.	M.g.d.	M.g.d.	M.g.d.	M.g.d.
1911	120 000	8	73	8.7	....	....	..
1912	124 000	10	76	9.5	13.0	....	..
1913	127 000	15	85	10.7	16.5	....	..
1914	130 000	9	86	11.2	15.1	14.3	25
1915	132 000	6	75	9.9	12.3	....	..
1916	145 000	6	84	12.1	18.3	16.5	32*
1917	152 000	6	86	13.0	17.5	....	..
1918	160 000	5	88	14.2	20.4	....	..

* Actual.

The maximum rates of demand which had occurred up to 1917 were as follows:

		Ratio to Av. Daily for Yr. (12.13 M.g.d.).
July 24–30, 1916.	Maximum weekly rate = 16.5 M.g.d.	136%
July 24, 1916.	Maximum daily rate = 18.3 M.g.d.	156%
July 30, 1916.	Maximum hourly rate = 31.9 M.g.d.	263%
July 24–27, 1916.	Maximum for four consecutive days = 16.71 M.g.d.	138%

SIGNIFICANT RATES OF CONSUMPTION, 1916.

Hour Ended.	Monday, July 24.	Tuesday, July 25.	Wednesday, July 26.	Thursday, July 27.	Friday, July 28.	Saturday, July 29.	Sunday, July 30.
				Minimum Rates.			
1 A.M.	8.40	9.32	9.00	8.24	8.62	8.02	8.82
2 A.M.	7.82	*7.04*	7.94	8.00	*7.04*	9.17	7.97
3 A.M.	*7.42*	8.12	*7.82*	8.06	8.42	8.10	*6.70*
4 A.M.	7.67	7.92	8.24	7.56	8.50	7.82	7.06
				Maximum Rates.			
6 P.M.	26.22	22.06	24.48	25.82	25.14	25.13	23.27
7 P.M.	29.51	*24.11*	*27.98*	*28.48*	*28.86*	*28.69*	*31.92*
8 P.M.	*29.69*	21.36	27.12	25.86	28.08	24.96	18.00
9 P.M.	19.81	15.30	17.06	20.34	18.12	16.54	14.43
Average Daily M.g.d.	*18.3*	16.0	16.8	16.6	16.8	16.6	14.9

Average for week (shown above) *16.5* M.g.d. (maximum weekly in year 1916).

(Note that the maximum rates for less than one hour were substantially greater than the rates here shown.)

Capacity of Reservoir, 10 000 000 Gallons. — Under normal conditions the capacity of the proposed reservoir would have been fixed at 25 to 30 million gallons, but in view of the conditions in the building market, induced by the war, it was felt necessary to

reduce this limit. The capacity adopted was determined by the amount of storage necessary to equalize the hourly fluctuation in domestic and industrial water consumption, provide storage which would facilitate the making of minor repairs at the Keowee Street pumping station, and meet the "1916 standard" fire supply requirements of the National Board of Fire Underwriters.

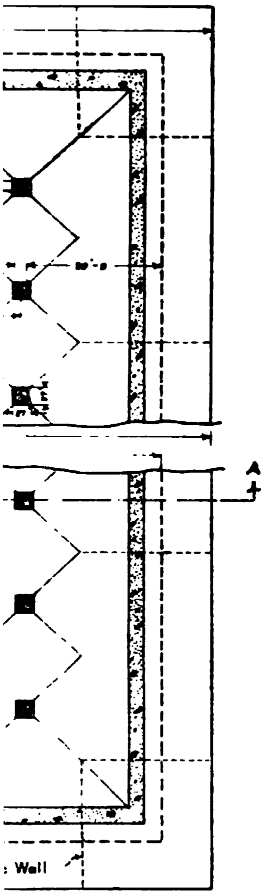
A study of the hourly fluctuation in demand indicated that during the period of heaviest consumption recorded (from July 1 to July 31, 1916) the storage capacity necessary to equalize the hourly demand was approximately 3 million gallons, the maximum and minimum requirements during this period being 3.3 and 1.2 million gallons, the average throughout the month 2.2 million gallons, or approximately 15 per cent. of the actual average daily consumption of 14.7 million gallons in the month of maximum demand, July, and 24.8 per cent. of the mean daily consumption for the entire year. To maintain a ten-hour flow of the maximum fire demand as prescribed by the 1916 standard of the National Board of Fire Underwriters required an additional storage capacity of approximately 7 million gallons. The sum of these amounts, aggregating 10 million gallons, was therefore adopted as the necessary storage capacity for the new reservoir.

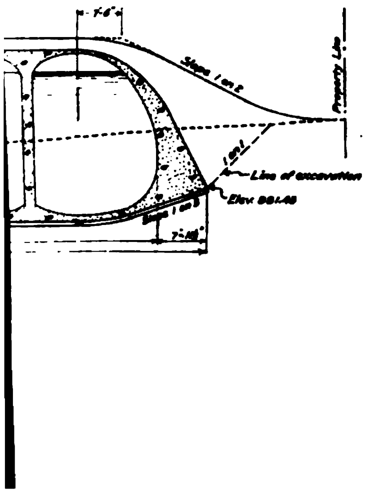
Design.

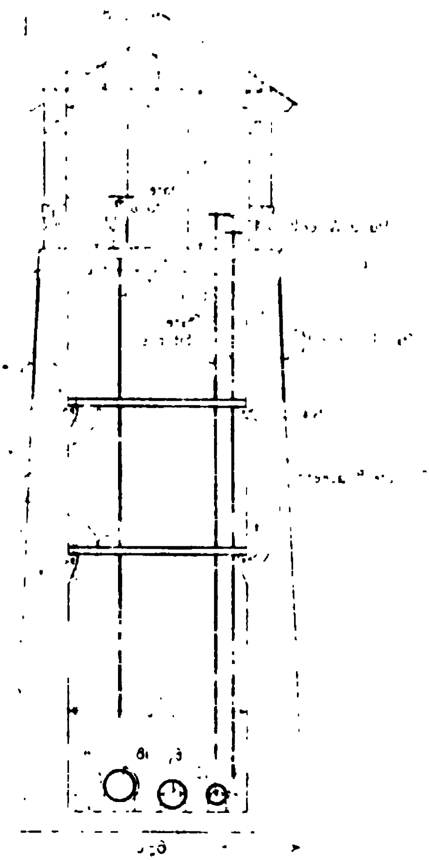
After preliminary studies, designs were prepared for a groined arch type of structure, as on the whole the most desirable and probably the cheapest type for this service, to be built of concrete 264.5 ft. long, 230.5 ft. wide, and 26.5 ft. deep in internal dimensions, and with a 23½ ft. depth to the flow line. A plan and sections of this structure are shown in Plates I, II, and III following.

Although the work was widely advertised and a considerable number of bids were looked for, but three bids were received, — all from local contractors, — and were opened on July 31, 1917. These bids amounted to \$164 592, \$188 805, and \$192 835, exclusive of the materials to be furnished by the city, which were estimated to aggregate the further sum of \$33 500. They were all in excess of the engineer's estimate of \$131 000, exclusive of materials to be furnished by the city. When it appeared that

PLATE I.
N. E. W. W. ASSOCIATION.
VOL. XXXIII.
METCALF AND BARNES ON
TEN-MILLION-GALLON RESERVOIR,
DAYTON, OHIO.







SECTION THROUGH
GATE HOUSE AND CHAMB

these local contractors were not familiar with groined arch construction, whereas they were experienced in the building of flat-slab roof construction, and were therefore ready to submit more advantageous figures upon a structure of the latter type, the bids were all rejected.

New specifications were prepared, permitting the submission of bids upon the engineers' designs and upon designs of the bidder, subject to the following requirements:

Requirements for Alternate Design.

General.

Section 7.16a. The capacity of the reservoir shall be ten (10) million gallons as computed with high water not higher than elevation 901.0. The depth of water shall not be less than twenty-three feet three inches (23 ft. 3 in.) nor more than twenty-four feet six inches (24 ft. 6 in.). The overall interior dimensions, general arrangement, and gatehouse details and location shall conform in general to the drawings hereto attached.

The quality of materials used, character of construction and other requirements, as contained in the specifications, shall apply to alternate design.

Soil Pressures and Unit Stresses.

Section 7.16b. The reservoir shall be designed to carry a superimposed load on the roof of 265 lb. per square foot, with side earth slopes as shown on the drawings of Metcalf & Eddy hereto attached.

In computing earth loads and pressures a cubic foot of earth shall be assumed to weigh 100 lb. The angle of repose shall be assumed as 30 degrees.

The maximum soil pressure shall not exceed 6 000 lb. per square foot.

The working unit stresses in the concrete and steel shall not exceed the allowable working stresses recommended in the final report of the Joint Committee on Concrete and Reinforced Concrete, 1916, for concrete having an ultimate compressive strength of 2 000 lb. per square inch. The methods of computation used shall in general conform with the methods outlined in said final report of the Joint Committee.

The tensile or compressive stress in the steel shall not exceed 16 000 lb. per square inch.

In calculating moments of resistance the tensile stresses in the concrete shall be neglected.

Outside Wall.

Section 7.16c. The outside wall, if of the arched type, shall conform to the design shown on drawing sheet No. 3 hereto attached,* for the groined arch type of reservoir; if a reinforced concrete or plain concrete type is adopted

* Numbers refer to plans accompanying specifications, all of which are not here reproduced.

the wall shall conform to the requirements herein outlined, subject to the approval of the Director.

The outside wall shall be designed so as to be self-supporting; and the stability and resulting stresses and soil pressures shall be computed on the basis, first, of the reservoir full of water with vertical earth load on wall and roof but no horizontal earth thrust against the wall; and second, of the reservoir empty with vertical earth load on wall and roof and horizontal earth thrust against the wall.

Floor.

Section 7.16d. The floor, if of the groined arch type, shall conform to the design shown on the drawings sheets Nos. 2 and 3 hereto attached; if of the flat type the floor shall be at least 8 in. in thickness and shall be reinforced with ½-in. square bars spaced 12 in. on centers in both directions, or the equivalent thereof, subject to the approval of the Director.

The floor shall be divided into panels or blocks according to the column spacing. The joint between adjoining blocks shall be made and supported as shown by " Details of Floor Joints " drawing sheet No. 3 hereto attached.

Columns.

Section 7.16e. If the roof is of a type other than the groined arch, the columns shall be of concrete reinforced with four vertical bars ¾-in. square, one in each corner, and with hoops ¼-in. round, spaced 12 in. on centers. The vertical bars shall extend at least 18 in. into the footing and into the roof slab. Means shall be provided for uniting the ends of each hoop so as to develop the full strength of the hoop. The column sections shall be 24 in. square, round or octagonal. If the groined arch roof is used the columns shall conform to the drawings shown on sheet No. 3 hereto attached, or the equivalent thereof, subject to the approval of the Director.

Roof.

Section 7.16f. The roof, if of the groined arch type, shall conform to the design shown on the drawings sheets Nos. 1 to 3, inclusive, hereto attached, or the equivalent thereof, subject to the approval of the Director; if of the reinforced, flat-slab type the dimensions of the capitals, drop panels and slabs shall at least be equal to those shown on the drawing sheet No. 7, " Flat-Slab Type — Alternate Design," hereto attached.* The reinforcement of the slabs may be according to the so-called " four-way, two-way, or circumferential system," and shall be designed to conform with the requirements hereinafter stated.

The spacing of the columns shall be not less than 17 ft. nor more than 20 ft. on centers.

Design of Flat-Slab Reinforcement.

Section 7.16g. The design of the steel reinforcement of the flat-slab roof shall conform to the following rules:

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* See note, page 225.

Let w = total dead and live load on roof = 365 lb. per square foot of roof.
L = span length of slab = distance center to center of columns — $\frac{2}{3}$ diam. of capital if circular, or $\frac{3}{4}$ width of capital if square.
b = slab width = distance center to center of columns.

The effective depth of the slab shall be taken as the distance from the face of the concrete in compression to the center of the tension steel nearest the compression surface in two-way reinforcing, and at mid-span in four-way reinforcing. Over the column in four-way reinforcing the depth to the center of gravity of all the steel cut by the section may be used.

Negative bending moment, in foot-pounds, in the column head sections $= .045wbL^2$; and in the mid-section $= .009wbL^2$.

Positive bending moments in foot-pounds in the outer section $= .0225wbL^2$; and in the inner section $= .0135wbL^2$.

If provision is made by reinforcement, to care for the negative bending moment in the outside walls from the roof slab, the end panels of the roof may be designed on the same basis as interior panels.

The sectional area of all bars crossing any section multiplied by the sine of the angle between the bars and the section under consideration, may be taken as effective at that section.

The point of inflexion shall be taken at a distance from the center line of columns equal to $\frac{1}{4}$ L + $\frac{1}{3}$ diam. of capital if circular, or $\frac{1}{4}$ L + $\frac{3}{8}$ side of capital if square, for slabs having drop panels.

The design shall provide and drawings shall show adequate provision by chairs, or other methods, for securing the reinforcement in place.

If bars are extended beyond the column capitals and are used to take the bending moment on the opposite side of the column, they must extend to the point of inflexion. Bars and diagonal bands used as reinforcement for negative moments shall extend on each side of the line drawn through the column center at right angles to the direction of the band a distance equal to 0.35 of the panel length — that is, the distance center to center of columns, and bars in the diagonal bands used as reinforcement for positive moments, shall extend on each side of the diagonal through the center of the panel a distance equal to 0.35 of the panel length. Bars spliced by lapping and counted as only one bar in tension, shall be lapped not less than 80 diameters if splice is made at point of maximum stress, and not more than 50 per cent. of the rod shall be so spliced at any point in any single band or in any single region of tensile stress. Continuous bars shall not all be bent up at the same point of their length, but the zone in which this bending occurs shall extend 20 diameters on each side of the assumed point of inflexion.

If straight bars only are used in any band, they shall extend 20 diameters beyond the inflexion point.

The maximum spacing of bars shall be not over 16 in. center to center.

The design of the roof reinforcement shall be in all respects satisfactory to the Director.

Proportions for Concrete Masonry.

Section 7.16h. If the outside wall is constructed of the arch type, or if a heavy plain concrete gravity section is used, the concrete in the outside wall and gate chamber may be Class B concrete. If, however, a reinforced concrete type of outside wall is adopted, the entire structure including the outside wall and gate chamber shall be constructed of Class A concrete. The proportions for these two classes of concrete are given in Section 7.5.

On October 5, 1917, the following bids were received:

	Unit Price Form of Contract.		Cost-Plus-Per-Cent-Profit-or-Fee Type.	
	Excluding Materials furnished by City.	Including Materials furnished by City.	Excluding Materials furnished by City.	Including Materials furnished by City.
Flat-Slab Type.				
Structural Concrete Company	$162 423	$199 660	....	....
Danis-Hunt Construction Company	93 000	133 935	$104 500	$134 832
J. I. Geiger & Miami Engineering and Construction Company	99 685	153 613	99 685	153 613*
Groined Arch Type.				
Price Bros. Company	$114 489	$143 310	....	....
J. I. Geiger & Miami Engineering and Construction Company	126 837	155 658	$126 547	$155 368*

* Divide difference of amount saved from upset price on 50% — 50% basis.

Contract was awarded to the lowest bidder, the Danis-Hunt Construction Company of Dayton, upon designs meeting the specifications though involving a radical modification in type of structure from that originally proposed.

The new plans provided for gravity side walls varying in height with the slope of the ground; a groined arch bottom sloping up on its periphery to meet the most economical wall sections; and a

PLATE IV.
N. E. W. W. ASSOCIATION.
VOL. XXXIII.
METCALF AND BARNES ON
TEN-MILLION-GALLON RESERVOIR,
DAYTON, OHIO.

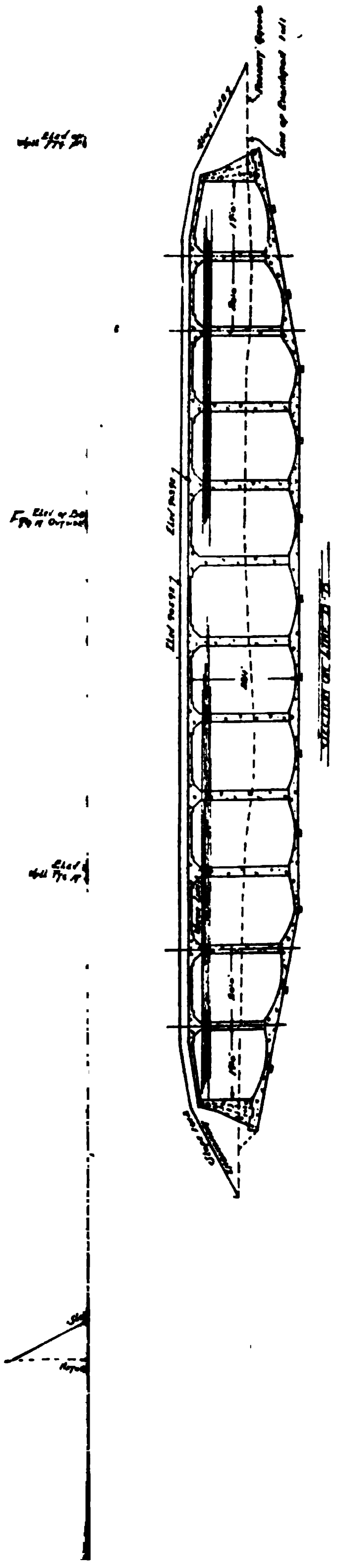

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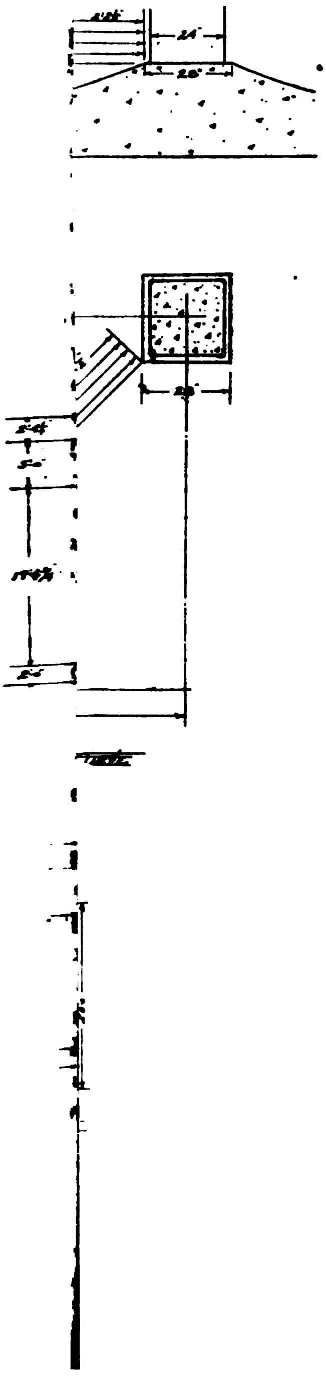
PLATE V.

N. E. W. W. ASSOCIATION.
VOL. XXXIII.

METCALF AND BARNES ON
TEN-MILLION-GALLON RESERVOIR,
DAYTON, OHIO.



flat-slab roof of the two-way system, supported on cylindrical columns 26 in. in diameter and 20 ft. on centers. The general type of structure is shown in Plates IV and V and Fig. 2 following.

The preliminary stages leading up to the adoption of the final design have been rehearsed here in some detail because it is interesting to compare the bids upon different types of structure and to note that purely local conditions determined the final choice of type. The local contractors had not had experience with the groined arch type, of structure, but had built many flat-slab floors and roofs; and it is also probable that the fact that these contractors had on hand a large supply of wooden forms, which had been used by them in flat-slab construction theretofore, was of substantial moment in determining the bids submitted by them and type of structure proposed. It seems probable that under normal conditions the groined arch design would have commanded the lowest figures, and that advantageous competitive bids for building the structures would have been received from a number of contractors outside of Dayton, as well as from local bidders; but under the abnormal local conditions a different result followed.

The writers are of the opinion that the groined arch type is to be preferred to the flat-slab type for such reservoir structures, on account of greater strength and permanence, but the bids received, under the local conditions then prevailing, were more than enough lower to offset this difference.

CONSTRUCTION.

Excavation. — Excavation was begun by the contractor on October 12, 1917, with Thew steam shovels of the "O" type, having a capacity of from 200 to 500 cu. yd. per day with a $\frac{5}{8}$ cu. yd. dipper, stripping the surface material and depositing it in storage piles adjacent to the work, by means of two-horse hopper-bottom wagons. Two steam shovels were used, — one substantially throughout the job; the other from November 17 to December 6, 1917, although it remained on the work until March 2, 1918. A Keystone excavator of from 100 to 250 cu. yd. capacity, manufactured by the Keystone Drilling Company of Beaver Falls, Pa., was also used during the periods from No-

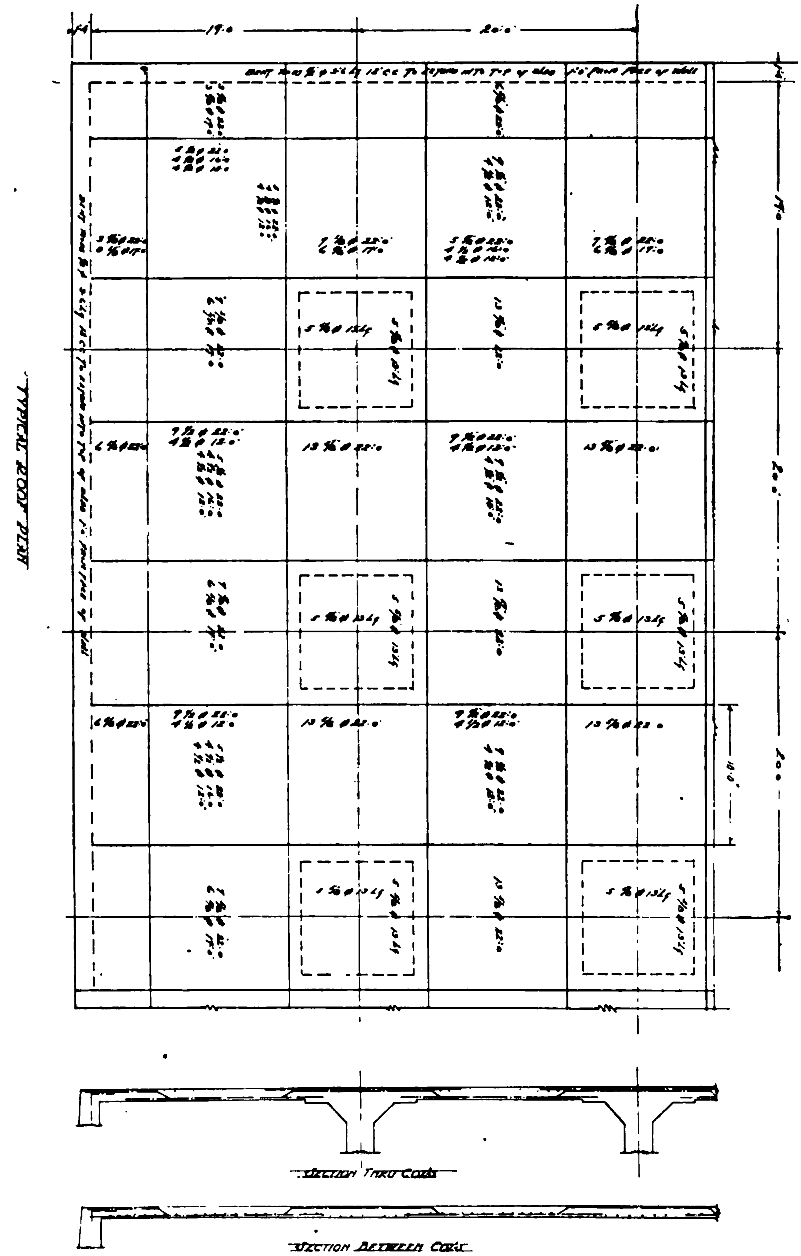


Fig. 2. Roof Slab Reinforcing.

vember 12 to December 1, 1917, and March 1 to 25, 1918. The latter machine consists of a tractor engine with trolley boom carrying a scoop shovel of 10 cu. ft. capacity and was used largely for trimming up the rough excavation made with steam shovel, prior to the final preparation of the foundation by hand. Some of the sand and gravel was handled on short haul by slip scrapers.

By these methods 25 000 cu. yd. of material were handled, 45 per cent. of it being delivered to the screening plant located within the lines of the reservoir, for use in concrete aggregates; 30 per cent. being stored and subsequently replaced as backfilling, over and against the completed reservoir; and 25 per cent. being placed directly in the embankment surrounding the structure.

The excavation and resurfacing work was sublet, it is reported, at the following figures:

12 000 cu. yd. 25c. per cubic yard for sand and gravel hauled from excavation to the screening plant.
13 000 cu. yd. 45c. per cubic yard for soil and dirty gravel hauled outside of reservoir walls.
10 000 cu. yd. 56c. per cubic yard from storage pile into backfill.
3 acres at $100 per acre for grassing and seeding.

At these prices the subcontractor must have suffered at least the loss of rental upon his equipment.

The surface and subsoil material consisted of a clayey gravel, varying in depth from 1 to 3 ft. Under this was found a clean, sound, and rather fine gravel. To it was added such coarser material as could be obtained at reasonable cost, from a nearby pit and by rail. All of the concrete aggregates, except about 1 800 cu. yd. of this coarser material, came from the site.

Contractor's Plant.

Screening and Washing of Concrete Aggregates. — The gravel excavated from the site was dumped from hopper-bottom wagons or slip scrapers on a sloping rack of flat bars with 2½ in. clear space. The material fell into a pit from which it was raised by elevator bucket and dumped into a similar bucket arranged with nozzles for washing the gravel, the muddy water overflowing to the waste channel, the washed material being discharged through a

gated opening upon an inclined piano-wire screen 3 ft. by 5 ft., with $\frac{3}{16}$ in. opening. This screen was made by the Manufacturers Equipment Company of Dayton, Ohio. This screen was protected by a series of wires stretched above the screen to divert the heavier material, the fall of which would have injured the

FIG. 3. SCREENING AND MIXING PLANT.

screen. By this means the material was separated into two grades, — sand and gravel.

A stiff-legged derrick with structural steel mast and boom, swung by a bull wheel, was erected at the northeast corner of the reservoir just outside of the structure. Its location was such that with its boom in a fixed elevation the clamshell bucket could cover the sand and gravel piles at the base of the screening plant, the sand and gravel hoppers of the mixing plant, the sand storage pile in the old gravel pit just north of and adjacent to the reservoir structure, and the gravel storage pile just east of the reservoir.

Mixing Plant. — The concrete mixing plant consisted of a Smith type mixer of one cu. yd. capacity, operated by steam

engine, with elevated measuring hoppers, operating platform and small cement storage shed, and with sand and gravel storage bins with hopper bottoms at a still higher level. The storage bins and water tank were fitted with steam pipe coils for use in freezing weather.

The concrete when mixed was discharged into an elevator with self-dumping hopper from which it was dumped into a second hopper located just above the elevated wheeling platform. This hopper was provided with a shear gate for controlling the loading of the concrete buggies.

Miscellaneous Plant. — A cement storage shed, blacksmith shop, tool and supply house, office and stables, all of temporary type, were erected by the contractor and connected with the high-service water supply and electric-lighting systems. A small saw mill was also installed, to assist in the making of forms, though it was used comparatively little. Simple devices were used for bending the structural steel.

Runways. — An elevated platform was erected along the north and west sides of the reservoir, just outside of the neat lines of the structure, from which was poured the concrete for a portion of the floor and walls, the balance of the concrete being poured from runways laid upon the roof forms.

ORDER OF CONSTRUCTION.

After the excavation had been made by steam shovel in the northwesterly corner of the site, the subgrade was prepared by hand shovel. The 8 in. x 12 in. concrete beams were then laid. Next, alternate floor units were placed, — the pier units of the inverted groined arch type, and the marginal units of barrel arch type, extending under the side walls. The concrete in the side walls was then placed in alternate units, one panel (20 ft.) in length, the concrete being poured monolithic from the base of the wall to the roof slab. The alternate floor units previously omitted were then placed, and when a sufficient area of the floor had set, to make working upon it possible, the forms for the columns and the roof were placed. As the slope of the floor of the inverted groined arch units was substantial, the contractor adopted

the expedient of setting iron bolts about 2 in. into the concrete, to support a wooden sill, upon which was then placed the studding to support the roof forms.

The columns were poured monolithic from the floor to the base of the capital, the capital of the column being poured with the roof slab. The roof was placed in sections covering two or more adjacent lines of piers, joints being broken on the mid-sections between the pier lines.

The effort was made to keep the concrete moist until thoroughly set. The difficulty in accomplishing this upon the roof slab, and the development of undesirable cracks where the concrete dried out too rapidly, has suggested to the writers that it would have been desirable to place a ridge of mortar, 1 in. or thereabouts in depth, around the margins of the completed slabs, in finishing the roof, to form shallow basins in which water might be kept standing until the roof concrete had set thoroughly.

To prevent undue leakage through contraction cracks at the ends of the side wall sections, deep tongues and grooves in the thick section of the wall, and 12 in. by $\frac{1}{8}$ in. by 9 ft. 9 in. steel plates through the mid-section of the upper thinner part of the wall were provided.

Forms.

Floor Forms. — The floor form consisted of four steel ribs of T section, bent to the form of the groin or arris, attached to the corners of a 28-in. square steel yoke, forming the base of the column, and suspended from a long wooden horse spanning the floor unit. The exterior forms of the alternate units first placed consisted of 8-in. planks on edge, with a strip slightly beveled and nailed to the upper part of the 8-in. plank, to form the rebate in the upper half of the slab joint, to receive the concrete of the alternate floor units. The perimetral edge of the floor unit rested upon the 8 in. by 12 in. sub-foundation beams previously referred to. In this manner a double-angle cut-off was formed, to prevent leakage. Furthermore the underlying beam served to make possible the introduction of an asphaltic mixture in the joint, at a later date, if it should be found that leakage was produced by

shrinkage cracks in the floor units, without danger of having the water in the reservoir blow this jointing material through the joint to the sub-foundation.

Wall forms were made of 2-in. plank, thoroughly braced with vertical studs secured at the bottom, tied through the concrete with twisted wire, and yoked on top.

FIG. 4. FLOOR AND ROOF FORMS.

To prevent the lifting of the back form of the side walls by the upward pressure of the plastic concrete as it was placed, ⅜-in. U-irons were inserted in the floor unit, which extended under the wall, to which the outside wall forms were anchored by twisted wire.

The roof column forms were of steel, built and leased by the Deslauriers Column and Mould Company of Cleveland, Ohio, of a type commonly used in building construction. The details of the column and capital forms are indicated by the accompanying photographs.

The roof forms were supported by 4-in. studs 5 ft. on centers, resting upon 4 by 4 in. sills, braced at intervals and stiffened by

occasional sway bracing and by bracing in horizontal planes approximately 5 ft. apart, as shown in the accompanying photograph.

On top of the wooden columns were placed longitudinal stringers 4 in. by 4 in., and upon them sections of grillage made

FIG. 5. COLUMN FORM.

up of strips of 2 in. by 3 in. scantling 2 in. apart, secured by cleats and chains, the chains being used so that when the cleats were removed the grillage could be nested in compact form for shipment. On top of this framework was tacked 28 gage sheet steel upon which the concrete was placed. Forms for the dropped panels over the columns were of wood, as appears in the accompanying photographs. This type of form lent itself to ready removal after the setting of the concrete.

FIG. 6. COLUMN FORM DISMANTLED.

FIG. 7. FORMS FOR COLUMN CAPITALS.

FIG. 8. GRILLAGE FOR ROOF FORMS.

FIG. 9. FORMS FOR DROPPED PANELS.

CONCRETE PROPORTIONS.

Two classes of concrete were used — Class A and Class B:

Class A. — One part by volume of cement and four parts of gravel, to which was added sufficient sand of variable grade, not exceeding two parts, to make a satisfactorily dense mixture.

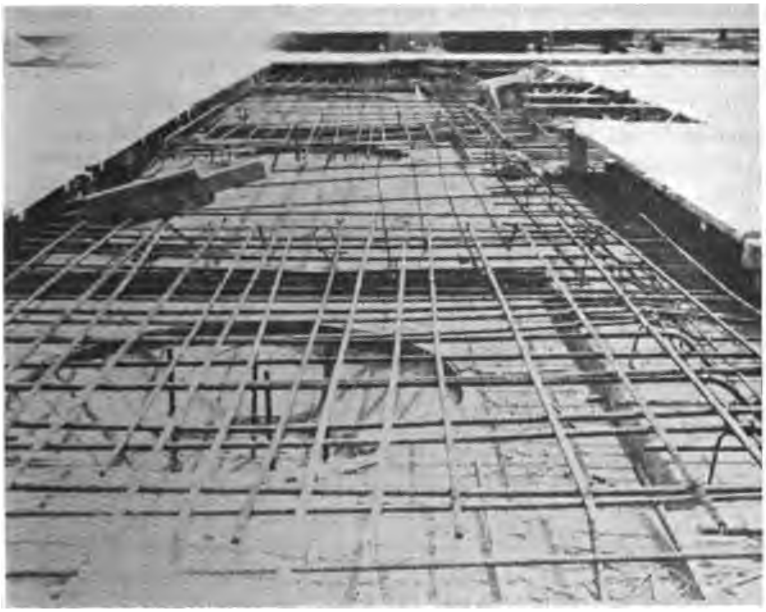


FIG. 10. REINFORCEMENT IN PLACE.

Class B. — One part by volume of cement and five parts of gravel, to which was added sufficient sand of variable grade, not exceeding three parts, to make a satisfactorily dense mixture.

Class A concrete was used throughout the structure, except in the walls. Class B concrete was used for the side walls, which were of heavy gravity section without reinforcement.

RATES OF PROGRESS.

Reference has already been made to progress upon the excavation, which was begun on October 12, 1917.

Most of the contractor's plant was assembled and placed during the latter part of November and early part of December.

The first cement shipment arrived on November 30.

Snow fell on December 6, and bad weather continued until December 19, when the work was suspended for the winter, except for one of the steam shovels, which was operated from time to time as weather permitted.

The number of men employed during the months of October, November and December varied from twenty to fifty.

On February 23, 1918, the work was resumed actively with a force of about sixty men, which was gradually increased to about one hundred.

The placing of concrete began March 11 and was completed June 27, 1918. There were placed 8 746 cu. yd. of concrete in seventy-nine days, out of eighty-six available working days, and eighty-one actual working days. The average rate of placing concrete was, therefore, 110 cu. yd. per day of concrete-pouring; 108 cu. yd. per working day, and 102 cu. yd. per available working day.

TABLE 2.

AVERAGE NUMBER OF MEN EMPLOYED DURING CHARACTERISTIC WEEK IN BUILDING THE LOW-SERVICE RESERVOIR.

	Week Ended.		
	April 20.	May 25.	June 8.
Yards of concrete placed	868	907	850
Number of employees:			
Preparing subgrade	10	7	..
Washing and screening sand and gravel	6	10	14
Carpenters	37	27	32
Mixing and placing concrete	22	32	31
Unloading and handling cement	3	3	1
Steel	6	4	4
General work	10	5	7
Total	94	88	89

The maximum amount of concrete placed in one week was 907 cu. yd., averaging for that week (May 20 to 25) 151 cu. yd. per day; the maximum amount on any single day being 226 cu. yd. on June 5.

The approximate number and distribution of men employed during the active progress of the placing of the concrete is shown by the tabulation on page 240, and the rate of progress on the different branches of the work by Fig. 11.

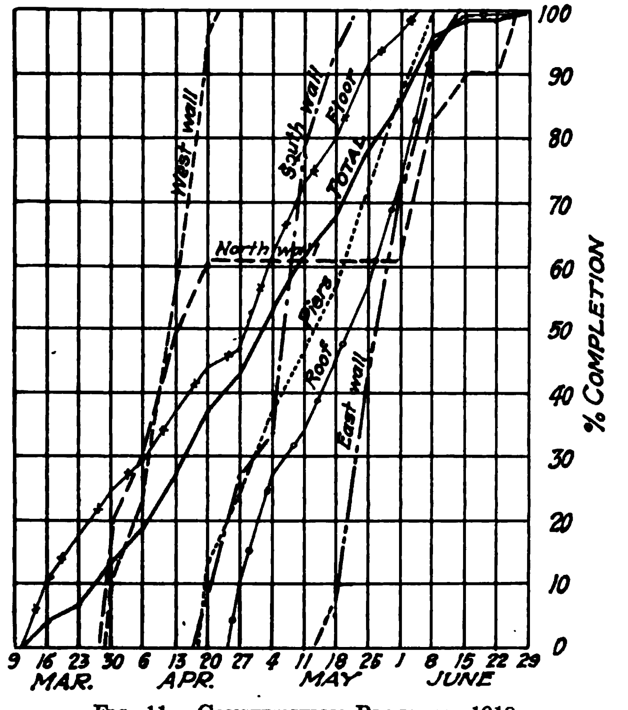


FIG. 11. CONSTRUCTION PROGRESS, 1918.

A reception was held in the reservoir on June 13, 1918, at which time opportunity was given to the public to thoroughly inspect the structure.

The reservoir was cleaned out on July 6, and on July 8 it was filled to a depth of about 11 ft., and one tank containing 80 lb.

of liquid chlorine was lowered into the water and its contents discharged, thus giving the water a dose of 25 lb. of chlorine per million gallons of water. Shortly thereafter the outlet valve was opened and the contents of the reservoir were drained in a period

FIG. 12. TYPICAL WALL SECTION.

of about eighteen hours. Men were then sent into the reservoir with a fire hose to wash the entire inner surface of the reservoir down. This took one working day, and on the evening of the same day refilling of the reservoir began and continued for three days, 2 million gallons, more or less, being permitted to overflow into the drain. The reservoir was then put into service, though

it was subsequently thrown out of service for three weeks for a test of leakage and for minor repairs upon the floor joints.

The leakage will be observed from time to time during the cold winter months, and if found to increase materially, the joints

FIG. 13. INTERIOR COMPLETED RESERVOIR.

around the unit pier sections will be treated with an asphaltic mixture.

The general character of the concrete was smooth, dense, and excellent, — thoroughly creditable to the contractor, the Danis-Hunt Construction Company which was experienced in reinforced concrete and flat-slab building construction.

When the reservoir was first tested the leakage was found to be at the rate of 23 in. vertically, or 864 000 gal. per day. The water was withdrawn and cracks were found along the center lines of the floor invert at certain places. These cracks were cut out and filled with mortar.

The reservoir was refilled on August 15, 1918, and the leakage was found to have been reduced to $2\frac{5}{16}$ in. vertically, or 88 000

TABLE 3.

DAYTON, OHIO. — LOW-SERVICE RESERVOIR. — RESIDENT ENGINEER'S BASIC ESTIMATE OF COST TO THE CONTRACTOR (CEMENT FURNISHED BY CITY).

	Contractor's Costs. Labor.	Material and Equipment.	Total Excluding Overhead.	Total Including 10% Overhead.*	Cubic Yards.	Unit Costs. Sub-divided.	Unit Costs. Total.
Excavation — by Subcontractor:							
1. Total estimated cost .. $14 450							
2. Less allowance account, concrete aggregate.. 3 000	$11 450	.....					
3. *By Contractor's Teams and Labor*	1 922	.....	$14 796	$16 276	13 000 cu. yd.	$1.25	$1.25
4. Cleaning up (one half total, balance charged to concrete).	1 424	.....					
Concrete (exclusive of cost of cement and steel) —							
Field Office Administration:							
5. Superintendent, 150 days......	1 500	.....					
6. Engineer, 3 months...........	450	.....					
7. Engineer, 2 months...........	400	.....	4 232	4 655	8 746 cu. yd. concrete	.53	.53
8. Carpenter foreman (prior to May 10)..................	400	.....					
9. Timekeeper and watchmen.....	1 482	.....					
Sand and Gravel:							
10. 12 000 cu. yd. excavated from site for aggregates (see above)	3 000	.....					
11. Screening and washing gravel from site.................	2 065	.....					
12. 1 800 cu. yd. washed gravel purchased....................	.....	$2 500	10 450	11 495	8 746 cu. yd.	1.31	1.31
13. Washed gravel, labor, unloading	660	.....					
14. Washed gravel, hauling.......	2 225	.....					
15. Mixing and placing...........	9 058	.....	9 058	9 964	8 746 cu. yd.	1.14	1.14

Carpenter Work on Forms and Runways:							
16. Floors	1 536	.....	1 536	1 690	3 425 cu. yd.	.49	Itemised Segregation.
17. North wall and gatehouse substructures	1 675	230	1 905	2 095	1 236 cu. yd.	1.70	
18. West wall	1 311	170	1 481	1 629	938 cu. yd.	1.74	
19. South wall	474	90	564	620	479 cu. yd.	1.29	
20. East wall	416	80	496	546	442 cu. yd.	1.23	
21. Roof	9 280	2 400	11 680	12 848	1 824 cu. yd.	7.05	
22. Piers	521	3 300	3 821	4 203	402 cu. yd.	10.46	
23. General	261	30	291	320	8 746 cu. yd.	.04	
24. *Total forms*	($15 474)	($6 300)	($21 774)	($23 951)	(8 746 cu. yd.)	....	2.74
25. Cement handling and storage	1 737	.....	1 737	1 911	8 746 cu. yd.	.22	.22
26. Steel bars, handling and placing	1 517	.....	1 517	1 669	8 746 cu. yd.	.19	.19
27. Equipment, hauling, erecting, repairing, and removing	4 090	6 000	10 090	11 099	8 746 cu. yd.	1.27	1.27
28. Cleaning up and general work (one half charge to excavation)	1 425	.....	1 425	1 567	8 746 cu. yd.	.18	.18
29. Total concrete exclusive of cement and steel	($45 483)	($14 800)	($60 283)	($66 311)	(8 746 cu. yd.)	....	($7.58)
30. Gatehouse superstructure	174	±1 000	1 174	1 291	....	....	....
31. Miscellaneous work — estimated	1 020	.....	1 020	1 122	....	....	....
32. Total cost to the contractor	$61 473	$15 800	$77 273	$85 000	....	....	....

Contract negotiations begun July 31, 1917.
Contract entered into October 8, 1917.
Excavation begun October 12, 1917.
Concrete begun March 11, 1918.

Work suspended December 20, 1917, to February 23, 1918.
Contract (except gatehouse, backfilling and grading) completed June 27, 1918.
Contract finally completed August 29, 1918.
Entire period of construction — active, 11 months.
Entire period of net working days (only), 145 days.
Concrete construction — available working days, 86.
Concrete construction — days pouring concrete, 79.

* *Note.* — That in addition to this 10% distributed allowance for contractor's overhead there have been separately included Items 5 to 9, aggregating $4 232, or 5.8%, covering Field Office Administration costs, making the total overhead allowance 16.4%.

TABLE 4.

DAYTON, OHIO. — LOW-SERVICE RESERVOIR. — RESIDENT ENGINEER'S ESTIMATED UNIT COST TO THE CONTRACTOR, INCLUDING 5.8 PER CENT. FIELD ADMINISTRATION ITEM AND 10 PER CENT. DISTRIBUTED ALLOWANCE, OR A TOTAL OF 16.4 PER CENT. CONTRACTOR'S OVERHEAD COSTS.

	Excavation other than Cost of Concrete Aggregates ($3 300) Included in Line 3 below.	Concrete.				Gatehouse.	Miscellaneous	Total.
		Floors.	Walls and Gate Chamber.	Piers.	Roof.			
Excavation and Backfill:								
1. By subcontract ($15 895)	$12 595	.....	.....	.....	.....	.....	.....	$12 595
2. By contractor's outfit	2 114	.....	.....	.....	.....	.....	.....	2 114
Concrete:								
3. Sand, gravel excavation ($3,300) 4. Screening and washing ($2 272) 5. Gravel purchased ($5 923)	.....	$4 500	$4 070	$526	$2 399	.....	.....	11 495
6. Mixing and placing	.....	3 900	3 530	454	2 080	.....	.....	9 964
7. Handling and storing cement	.....	748	676	89	398	.....	.....	1 911
8. Handling and placing steel	.....	222	73	122	1 252	.....	.....	1 669
9. Equipment	.....	4 350	3 925	510	2 314	.....	.....	11 099
10. Field office administration	.....	1 822	1 648	214	971	.....	.....	4 655
11. Forms — Labor and materials	.....	1 815	5 003	4 218	12 915	.....	.....	23 951
12. Cleaning up	1 567	614	554	72	327	.....	.....	3 134
13. Miscellaneous work	.....	.....	.....	.....	.....	.....	$1 122	1 122
14. Gatehouse	.....	.....	.....	.....	.....	$1 291	.....	1 291
15. Total cost to contractor	$16 276	$17 971	$19 479	$6 205	$22 656	$1 291	$1 122	$85 000
Materials furnished by city:								
16. Cement, 12 280 bbls. ($2.14 net)	.....	$10 950	$8 190	$1 290	$5 840	.....	.....	$26 270
17. Steel, 152.52 tons ($80.51)	.....	1 630	540	900	9 210	.....	.....	12 280
18. Pipes and fittings	.....	.....	867	.....	.....	.....	.....	867
19. Lime for waterproofing	.....	372	.....	.....	.....	.....	.....	372
20. Grassing	$150	.....	.....	.....	.....	.....	.....	150

21. Miscellaneous	.....	205	186	24	194	40	511	1 160
22. Miscellaneous — Sewer	.....	.....	.....	.....	.....	.....	508	508
23. Miscellaneous — Self-recording level gage	.....	.....	.....	.....	.....	.....	198	198
24. Total materials furnished by city	$150	$13 157	$9 783	$2 214	$15 244	$40	$1 217	$41 805
25. Contractors cost plus cost to city of materials furnished	16 426	31 128	29 262	8 419	37 900	1 331	2 339	126 805
26. Yardage — Cubic yards	‡13 000	3 425	3 095	402	1 824	.....	.....	8 746 (Concrete)
Unit Costs (see Note † below):								
27. Work done by contractor	$1.25	$5.24	$6.29	$15.44	$12.42	$0.15	$0.13	$9.72
28. Materials furnished by city	.01	3.84	3.16	5.51	8.36	.....	0.14	4.78
29. Total †	$1.26	$9.08	$9.45	$20.95	$20.78	$0.15	$0.27	$14.50

Summary of Unit Costs of Concrete to Contractor Plus Materials Furnished to Him by the City.

Concrete:					
30. Sand and gravel	.....	$1.31			
31. Mixing and placing	.....	1.14			
32. Handling and storing cement	.....	.22			
33. Equipment	.....	1.27	$4.65	$4.65	$4.65
34. Cleaning up (one half charged to earth)	.....	.18			
35. Field office	.....	.53			
36. Handling and placing steel	.....	.06	.02	.30	.69
37. Forms	.....	.53	*1.62	10.49	7.08
38. Materials furnished by city	.....	3.84	3.16	5.51	8.36
	.....	$9.08	$9.45	$20.95	$20.78

* Labor and materials for north and west walls + gatehouse foundation cost, $1.71; labor and materials for south and east walls (Lighter Section), $1.27.

† Excavation cost based upon cubic yards of excavation other than for concrete aggregates; concrete costs based upon cubic yards actually involved in different classes of work, such as floor, walls, piers, and roof; gatehouse superstructure and miscellaneous costs based upon total amount of concrete, 8 746 cu. yd; total unit cost based upon total concrete, 8 746 cu. yd.

‡ Excluding 12 000 cu. yd. of sand and gravel used as concrete aggregates and included under concrete cost items.

TABLE 5.

DAYTON, OHIO. — LOW-SERVICE RESERVOIR. — RESIDENT ENGINEER'S ESTIMATED UNIT COST TO THE CITY.

	Excavation.		Concrete.				Gatehouse.	Miscellaneous.	Totals.
	Loam.	Earth.	Floors.	Walls and Gate Chamber.	Piers.	Roof.			
Excavation	$10 000	$15 000	.....	.....	.....	.....	.....	.....	$25 000
Grassing (half done)	150	.....	.....	.....	.....	.....	.....	.....	150
Handling cement	.....	.....	$2 560	$1 915	$300	$1 365	.....	.....	6 140
Concrete	.....	.....	10 275	18 570	5 025	22 800	.....	.....	56 670
Handling steel	.....	.....	400	.....	.....	3 415	.....	.....	3 815
Handling plates	.....	.....	.....	87	.....	.....	.....	.....	87
Handling metal and pipes	.....	.....	.....	400	.....	.....	.....	.....	400
Dressing concrete	.....	.....	.....	79	.....	.....	.....	.....	79
Unloading lime	.....	.....	24	.....	.....	.....	.....	.....	24
Gatehouse	.....	.....	.....	.....	.....	.....	$1 500	.....	1 500
Cleaning up	200	300	196	177	27	100	.....	.....	1 000
Total payment to contractor	$10 350	$15 300	$13 455	$21 228	$5 352	$27 680	$1 500	.....	$94 865
Materials furnished by city, cement, 12,260 bbl., $30 690 less sack credits, 4 420	.....	.....	$10 950	$8 190	$1 290	$5 840	.....	.....	$26 270
Steel, 152.52 tons	.....	.....	1 630	540	900	9 210	.....	.....	12 280
Pipes and fittings	.....	.....	.....	867	.....	.....	.....	.....	867
Lime for waterproofing	.....	.....	372	.....	.....	.....	.....	.....	372
Grassing	$150	.....	.....	.....	.....	.....	.....	.....	150
Miscellaneous	.....	.....	205	186	24	194	$40	$511	1 160

Miscellaneous — Sewer	.....	.....	.....	.....	.....	.....	.....	508	508
Miscellaneous — Self Recording level gage	.....	.....	.....	.....	.....	.....	.....	198	198
Total materials furnished	$150	.....	$13 157	$9 783	$2 214	$15 244	$40	$1 217	$41 805
Land	.....	.....	.....	.....	.....	.....	.....	7 030	7 030
Engineering (6%), administration (5%)	.683	994	1 730	2 016	492	2 790	100	536	9 341
Total cost to the city	$11 183	$16 294	$28 342	$33 027	$8 058	$45 714	$1 640	$8 783	$153 041
Yardage — Cubic yards	5 000	20 000	3 425	3 095	402	1 824	(8,746 cu. yd. conc.)		8 746
Unit cost to city for:									
Work done by contract	$2.07	$0.76	$3.93	$6.86	$13.31	$15.17	$0.18	.....	$10.85
Materials furnished	.03	.....	3.84	3.16	5.51	8.36	.....	$0.14	4.78
Land	.....	.....	.....	.....	.....	.....	.....	.80	.80
Engineering and administration	.14	.05	.51	.65	1.22	1.53	.01	.06	1.07
Total per cubic yard	$2.24	$0.81	$8.28	$10.67	$20.04	$25.06	$0.20	$1.00	$17.50

Total per million gallons of reservois capacity (10 m.g.)	$15 300
Total per square foot of water surface (60 917 sq. ft.)	2.51
Total per acre of water surface (1.4 acres)	109 300

gal. per day. Since that time the reservoir has been in active service, and the latest observation upon leakage, November 20, 1918, or thereabouts, indicated a loss of 1¼ in. vertically, or 48 000 gal. in twenty-four hours.

Cost.

The wages paid by the contractor increased progressively from 30c. to 38½c. per hour for unskilled labor; from 50c. to 60½c. per hour for carpenters; from 55c. to 65c. for engine men; and from 60½c. to 70c. for foremen. Teams were paid 60c. per hour.

It may be noted that in 1918 (except from April 2 to 8) wages were based on ten hours of work at eleven hours' pay, equivalent to time and one-half for the hours worked, in excess of the normal eight-hour working day.

In Table 3 is shown the basic estimate of cost to the contractor of doing this work, exclusive of the materials furnished by the city, and in Table 4 these costs have been segregated to show the total and unit costs of the concrete in floors, walls, roof and piers, with and without materials furnished by the city. In Table 5 is shown the estimated cost to the city.

	Contractor's Cost (Excluding Profit) Plus Cost to City of Materials Furnished by It to Contractor.	Total Cost to City of Dayton.	
		Excluding Land and Engineering.	Including Land and Engineering.
Gross cost	$126 805	$136 670	$153 041
Cost per cubic yard of concrete (8 746 cu. yd.)	14.50	15.63	17.50
Cost per million gallons of net water capacity	12 680	13 667	15 300
Cost per square foot of water surface (based upon 60 917 sq. ft. of water of 23.5 ft. average depth)	2.08	2.24	2.51
Cost per acre of net water surface (60 917 sq. ft. or 1.4 acres)	90 600	97 700	109 300

TABLE 6.

DAYTON, OHIO. — TEN-MILLION-GALLON LOW-SERVICE RESERVOIR. — CONSTRUCTION UNITS GROINED ARCH (INVERTED) FLOOR; INSIDE DIMENSIONS 258 FT. x 238 FT.; PIERS 26 IN. DIAM., 20 FT. C.C. GRAVITY SIDE WALLS; WATER SURFACE (NET) 60 917 SQ. FT.; REINFORCED CONCRETE SLAB ROOF: WATER DEPTH 23.5 FT., AVERAGE.

	Concrete.		Steel Reinforcement.				Cement.			
				Lb. per Sq. Ft.					Barrels per Cu. Yd. of Concrete.	
	Cubic Yards.	Equivalent Depth on Internal Area of Reservoir, Ft.	Pounds of Steel.	Outside Face of Wall at Top. (61 404.)	Inside Face of Wall. (Gross.)	Lb. per Cu. Yd. Concrete.	Proportions.	Barrels.*	Hypothesis A.	Hypothesis B.
Floor (incl. wall base)	3 425	1.51	40 550	0.64	0.66	11.8	1:2:4	4 450(?)	1.30	1.50 ±
Walls and gate chamber	3 095	1.36	13 720	0.22	0.22	4.4	1:2½:5	4 515(?)	1.46	1.24 ±
Roof	1 824	.80	228 440	3.63	3.72	125.0	1:2:4	2 715	1.49	1.50
Piers	402	.18	22 490	0.36	0.37	56.0	1:2:4	600	1.49	1.50
Total	8 746	3.85	305 200	4.85	4.97	34.9	....	12 280	1.40	1.40

* These records are not precise in any event, and they may be inaccurate. The keeping of the correct record of subdivision of bags of cement on different parts of the structure was very difficult. The " Hypothesis A " results are based upon the actual recorded segregation of cement used in about 38% of the floor masonry, 11% of the walls, 25% of the roof, or on 25% of the total masonry. " Hypothesis B " results represent the approximate theoretical division.

The total cost to the contractor is estimated at the sum of $85 000 (excluding profit item and materials furnished to contractor by the city); the cost to the city at the sum of $153 041 (including $7 030 for land, $41 805 for materials, and $9 341 for engineering and city administration). This results in the unit costs on page 250.

In Table 6 are given the amount and equivalent depths of concrete; the total weight and pounds of steel reinforcement per square foot of internal area of the reservoir; the number of barrels of cement and amount used per cubic yard of concrete.

Acknowledgments.

The work was executed under the authority and direction of Col. H. M. Waite, member American Society of Civil Engineers, city manager at its inception; Mr. J. E. Barlow, member American Society of Civil Engineers, director of Public Service, who succeeded Mr. Waite as city manager when the latter entered the military service in the spring of 1918; and Mr. H. C. Wight, member American Water Works Association, superintendent of the Division of Water, all of whom took active and helpful interest in the work and its progress.

The Danis-Hunt Construction Company was the contractor, Mr. Benjamin G. Danis having general supervision of the work. The alternative design submitted by the contractor was prepared by the company's engineer, Mr. Nelson J. Bell, under the general direction of Mr. Danis.

The original and modified designs were prepared by Mr. Frank A. Marston, of Metcalf & Eddy, who were the designing and supervising engineers upon this work.

The construction was in the immediate charge of Mr. Barnes; Mr. Gilman W. Smith, former division engineer of the American Bridge Company, was resident engineer, — and was succeeded, when he entered the government war service, by Mr. David A. Hartwell, city engineer and formerly chief engineer of the Sewage Disposal Commission of the City of Fitchburg, Mass.

Summary.

1. A covered masonry reservoir of 10 million gallons capacity was built for the Water Department of the City of Dayton, Ohio, in the year 1917–18, to equalize the hourly fluctuations in water demand; to facilitate the making of minor repairs at the pumping station; and to provide fire service storage capacity corresponding to the 1916 Standard of the National Board of Fire Underwriters.

2. The variation in rate of pumping at the main pumping station, to meet the demands of domestic, commercial, and industrial water service, was from about 6 million to 35 million gallons per day. The storage required to equalize the hourly variations was approximately 3 million gallons, or 25 per cent. of the average daily water consumption.

3. The fire supply storage capacity required by the National Board of Fire Underwriters (1916 Standard), corresponding to a ten-hour flow at maximum fire demand, was approximately 7 million gallons.

4. The sum of these two amounts (3 million and 7 million gallons) determined the capacity of the structure, which was reduced to the minimum on account of the difficulty and high cost of construction during war times.

5. The reservoir was built of concrete with walls of gravity section; inverted groined arch floor with 8-in. crown thickness; and 26 in. reinforced cylindrical concrete columns varying in length from about 20 ft. to 26 ft., supporting a flat-slab concrete roof $8\frac{3}{8}$ in. thick, reinforced with corrugated bars on the two-way system.

The original design prepared by the engineers for this work contemplated the construction of a groined arch floor and roof type of structure, with lighter walls than those finally used. This design was modified, however, on account of war conditions which made it impossible to secure outside bids and on account of the fact that the local bidders were more familiar with and better equipped to build the flat-slab roof construction and were therefore ready to submit relatively lower figures upon this type of construction than upon the groined arch structure. The unusual saving in cost here found justified the acceptance of a type of structure believed to have a somewhat smaller factor of safety and shorter life.

6. The method of performing the work is described in the text and illustrated by plates and photographs.

7. The total cost of the work to the contractor, excluding profit but including the cost of the materials furnished to him by the city, was $126 805, equivalent to $14.50 per cu. yd. of concrete; $12 680 per million gallons of net storage capacity; $2.08 per sq. ft. of net water surface, and $90 600 per acre of net water surface, — the water surface being approximately 60 917 sq. ft., or 1.4 acres, and its depth averaging approximately 23.5 ft.

8. The total cost to the city of Dayton, including the land and engineering, was approximately $153 041, equivalent to $17.50 per cu. yd. of concrete; $15 300 per million gallons of net water capacity; $2.51 per sq. ft. of water surface, and $109 300 per acre of water surface.

9. The character of the finished work was excellent, the concrete being dense and reasonably smooth.

10. The leakage of the finished structure was found to be $2\frac{5}{16}$ in. vertically, or 88 000 gal. per day, and three months after putting the reservoir into service $1\frac{1}{4}$ in. vertically and 48 000 gal. per day.

Discussion.

Mr. Caleb M. Saville. Mr. Barnes spoke of a method for keeping the top of the chamber damp or wet. I would say that we are constructing a groined arch chamber, using groined arch construction. We are finding it very advantageous to keep the chambers full of water all the time. We keep it up to the top of the arch. It makes it very convenient.

Mr. Frank L. Fuller. Mr. Barnes told me that I might show a slide of the roof of a 1 600 000 gal. covered reservoir, flat slab, which was constructed for the town of Webster in 1914, which, in connection with Mr. Barnes's very interesting account of this much larger reservoir, may be of interest. [*Stereopticon picture is shown on screen.*]

The side walls were rectangular, a foot and a half thick at the bottom and a foot thick at the top; the slab was a foot in thickness; all walls were made of concrete.

There is a ring which perhaps you may not be able to distinguish, which is 1½ in. in diameter and welded. I think the diameter was 5 ft. The piers were 16 in. square, and on to them were hooked these radial bars, which were ¾ in. Intermediate was various other reënforcement, so that the roof has shown no cracks, and fortunately has done very good work.

The total cost of the reservoir was $20 020, and the cost per thousand gallons was figured at $12.50. I think the cost of Mr. Barnes's reservoir, as I remember his figures, was about $12.68, and I think those figures coincide very closely. These prices were probably too low. The people that built this reservoir, although they were perfectly capable of doing almost any kind of a job, had not had much experience in such work. For instance, the excavation was 62 cents a cubic yard; the rock excavation, $4; concrete in the walls and footings, $10; cut-off wall around the piers, $10.50; column heads and foundation, $11.25; roof, $12.25; the bottom, $8; reënforcing steel in columns and foundation, 3¾ cents; in the side walls, 3 cents; in the roof, 4 cents. The pipe laying was 75 cents — that was 20-in. pipe.

Those are the principal items. And, as I said, the total cost was $20 020. The wall was reënforced by round bars, and the columns also by round bars with 1-in. corner.

I have the cost per thousand gallons of several other forms of reservoir roof. I do not know whether this reservoir could have been built cheaper if it had been built on the groined arch principle; I never figured that out to see what their prices would have been, and I do not know. It seems to me that the circular from of reservoir is the most economical and the most practical, and either a flat slab or something other than groined arch construction would fit better.

I have built several circular reservoirs, but never a groined arch roof on a circular reservoir. I have built some on some rectangular reservoirs. But it seems to me that a groined arch roof would not fit a circular reservoir very well.

I should have said that Mr. Sanford E. Thompson designed the reservoir.

Mr. Morris Knowles. It appears from the pictures that Mr. Barnes showed us that the floor slabs were formed with centers

coincident with the center of the pier, the slabs parallel with the line of the piers and midway between the lines of piers. If this be so, it appears that the process of screeding would be rather difficult, and it would be interesting if Mr. Barnes would explain the method used.

Mr. Barnes. If you notice the floor forms in one of the photographs; they were made of T-irons swung from a yoke that was hung from a long 22-ft. horse over the top, and the ends of those T-irons were held to the square form forming the outside of the unit. They used a long screed, about 21 ft. long, and those ribs as forms, and there was very little difficulty, with a strong man on either end and one in the middle, in preventing sagging from the screed, then finishing with the ordinary trowel when the concrete was dense enough to permit it.

Mr. Knowles. The T-iron had to be elevated at the last to finish the surface?

Mr. Barnes. At the very end it was withdrawn and a little mortar put into the space left by the vertical part of the T. It worked very well, apparently, with a good strong arm on either end of the screed..

SCHOHARIE DEVELOPMENT, CATSKILL WATER SUPPLY SYSTEM FOR NEW YORK CITY.

BY J. WALDO SMITH, CHIEF ENGINEER, BOARD OF WATER SUPPLY, NEW YORK CITY.

Construction work for the Schoharie development is now under contract. This source is a part of the original project to secure a supply of not less than 500 million gallons of water a day from the Catskill Mountain sources, as planned by the Board of Water Supply and approved by the Board of Estimate and Apportionment of the city of New York in 1905. The original plan has been amended in detail, or perhaps it may rather be said that the plan as now being constructed has developed somewhat differently than originally outlined. The total supply for the Catskill aqueduct will be obtained from the Esopus and Schoharie sources — not less than 250 million gallons a day from each — at a less cost than was originally estimated for securing the same amount of water from the three sources of Esopus, Rondout, and Schoharie creeks.

The Esopus watershed development, which will furnish not less than 250 million gallons per day by the construction of the Ashokan reservoir, has been completed. The Catskill aqueduct, having a capacity of not less than 500 million gallons a day, and the necessary appurtenant works have also been completed. These, together, constitute the first stage of construction and have been in continuous operation since January 27, 1917, the first Catskill water having been delivered to the city on December 27, 1915. These works were turned over to the operating department on August 1, 1917.

The Schoharie watershed is adjacent and contiguous on the north to the Esopus watershed, the divide being the main ridge of the Shandaken Mountains. Drainage from the Esopus water-

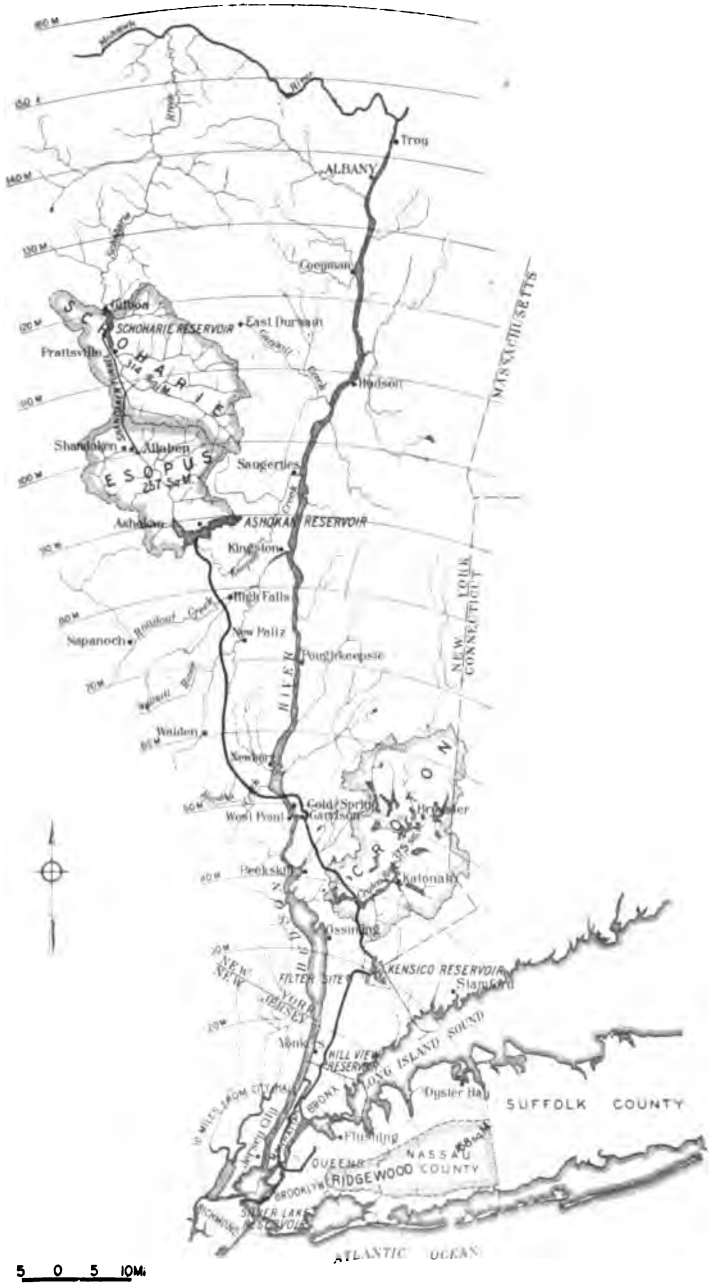


Fig. 1. Schoharie and Esopus Drainage Areas, City of New York Water Supply.

shed is naturally through Esopus Creek eastward into the Hudson River. Drainage from the Schoharie watershed, on the other hand, is northward into the Mohawk River. The general elevation of the upper reaches of Schoharie Creek is slightly higher than the Esopus Creek, so that an impounding reservoir and a long tunnel through the divide are the works that will be necessary to join the Schoharie watershed to the Catskill system. Thus the Catskill system will be extended northerly 36 miles from the Ashokan dam, making the total over-all distance of the Catskill system, from the Gilboa dam to the terminal reservoir in Staten Island, 156 miles.

The waters of Schoharie Creek will be impounded in a reservoir of 20 billion gallons capacity, formed by the construction of a dam in the town of Gilboa, Schoharie County, the flow line of the reservoir being at an elevation of 1 130 ft. above sea level. The water will then be diverted from this reservoir through an 18-mile tunnel under the Shandaken Mountains into the upper reaches of Esopus Creek, at the village of Allaben, Ulster County, where the elevation is about 969 ft. The Schoharie waters, having thus been discharged into the natural bed of Esopus Creek, will join the natural flow of Esopus Creek and follow the natural stream bed for a distance of 11 miles into the Ashokan reservoir, where it is available for the Catskill aqueduct. Thus, in effect, the Schoharie, with its drainage area of 314 square miles above the dam, will be added to the drainage area of the Esopus Creek, which is 257 square miles above the Ashokan dam, forming together practically one drainage area of 571 square miles.

The Schoharie reservoir, of 20 billion gallons storage capacity, is very small for the extent of its contributing area and would be insufficient had not the Ashokan reservoir been constructed of the largest practicable size, 128 billion gallons, which provides for more storage of Schoharie water in the Ashokan than will be provided in the Schoharie reservoir itself. It is therefore seen that the Schoharie reservoir is, in effect, a large diverting reservoir, and it will be so operated.

The Schoharie tunnel will be constructed so as to have a carrying capacity of approximately 600 million gallons of water a day. With this arrangement our studies indicate that during the high-

est floods of nearly every year there will be a waste of a few days' duration, both from the Schoharie reservoir and the Ashokan reservoir. Studies also indicate that during a series of normal years the Schoharie and Esopus, with these two reservoirs, will supply about 600 million gallons a day, securing upward of 80 per cent. of the total flow of the Schoharie Creek and upward of 80 per cent. of the total flow of the Esopus Creek. Studies also show that during a series of dry years, such as the period around 1880, deduced from comparison with Croton records and a study of the long-time rainfall records from New York to Albany, a supply of 500 million gallons per day can surely be secured. During such a dry period or any subnormal year the total flow of both streams will be impounded.

The complete Catskill system, with the Schoharie and Ashokan impounding reservoirs, together with the Kensico emergency reservoir near the city, will have the following features:

Reservoir.	Drainage Area. Sq. Miles.	Reservoir Area. Sq. Miles.	Available Storage. Million Gallons.	Probable Mean Stream Flow. Million Gallons a Day.
Ashokan storage	257	12.78	128 000	361
Schoharie storage	314	1.83	20 000	406
Catskill Mt. sources	571	14.61	148 000	767
Kensico emergency	22	3.47	29 000	18
Total Catskill system	593	18.08	177 000	785

These large yields are due to the generally high elevation of the watersheds and their steep and rocky character. While there are no Alpine heights, the watersheds are composed almost entirely of mountainous ridges covered with wild forest growths and outcropping ledges of shale and sandstone rocks cast up in steep and rugged slopes. There are no mountain peaks over 4 000 ft. in elevation, but the ridges which approximate this elevation for the most part and the intervening valleys in which the tributaries have their sources lie at elevations upward of 2 000 ft. The rainfall is abundant and quickly finds its way to the watercourses. There are generally large freshets in the spring, due to heavy rainfalls in connection with the melting of the deep snows,

with a complementary summer flow which for several months in most years is negligible in amount. Of the 47-in. depth of rainfall in a year on the Esopus watershed, 29.5 in. (63 per cent.) appears as stream flow, while the Schoharie, with only 39.5 in. of rainfall, yields 27.2 in. (69 per cent.) as stream flow. Compared with these, from published data the Croton yields 22.4 in. of stream flow and the Wachusett watershed, of the Boston supply, yields but 21.3 in. of stream flow, on the average.

The character of the Schoharie water is practically the same as that of Esopus Creek, both being of the greatest excellence for potable and domestic purposes. The water is soft, as there are no limestone outcrops, the bed rocks being entirely of shale and sandstone. The Schoharie and Esopus watersheds are dotted here and there by small villages, and the population is small and of a rural character. The villages within the Schoharie watershed are quite well known and may serve to locate the district. They are Hunter, Windham, Prattsville, and Grand Gorge, in Greene, Delaware, and Schoharie counties. A sanitary survey of the watersheds shows a permanent population on the Esopus of 5 339, with an additional summer population of 5 674, giving a density of population for Esopus of 21 for permanent population and a total of 43 per square mile for the total summer population. On the Schoharie the permanent population is 8 792, with an additional summer population of about 6 000, giving a density of population of 28 per square mile of permanent population and 48 per square mile of total summer population. These densities compare very favorably with published information on other watersheds. There is no probability of an appreciable increase of population, as the census figures indicate that there has been no increase in these townships for several decades and, in many cases, there has been a decrease.

The estimated cost of the Schoharie development with the dam at Gilboa is $22 175 400. Having moved the dam site downstream from the approved location at Prattsville to Gilboa, and having changed also the proposed location of the tunnel to Esopus Creek, it was necessary to have the amended plan approved by the constituted authorities. This amended plan with the dam at Gilboa was approved by the Board of Water Supply on December

21, 1915, by the Board of Estimate and Apportionment on January 31, 1916, and by the State Conservation Commission on June 6, 1916.

It is interesting to note — and this was a very forceful argument in proceeding with the construction work on the Schoharie at this time of excessive prices — that similarly, as the introduction of Esopus water to the city in 1917 saved the city $1 300 000 a year for pumping water from sources, so also will the introduction of Schoharie water, about the end of 1924, again save the city that amount, or more, because at that time, undoubtedly, pumps will be in full operation again, the pump supply now being used as a reserve to take up the increased demand from year to year, and as a reserve in case of emergency. This amount saved for pumping will more than meet the interest and sinking fund charges for the Schoharie project, and the city will get the permanent works, delivering 250 million gallons of water a day, against the 150 million gallons pumped, and it will also have the pump supply system in reserve.

The Catskill Creek watershed, which the city had the necessary authority to develop, was put to one side as a possible future source of supply in case of necessity because of the excessive cost of the works, estimated at $41 880 000 for a supply of 120 million gallons of water a day.

The Rondout Creek watershed, which the city also had the necessary authority to develop, was abandoned in 1914 because no location could be found where the foundation conditions were suitable for a dam. At the most favorable site a preliminary estimate showed that the cost of the works would be excessive, — $22 111 000 for a supply of 140 million gallons of water a day.

Preliminary Work and Acquisition of Property.

The land-taking surveys for the Schoharie work were begun in July, 1916, and detailed subsurface investigations by borings for the tunnel location and for the dam foundation were prosecuted in 1916 and 1917. This work was at first concentrated on the tunnel, as it will take longer to construct than to build the dam. There were 16 800 lin. ft. of borings made in definitely fixing the

tunnel line, grade and shaft sites, while an additional 8 400 lin. ft. of borings were made at the Gilboa dam site, these together totaling 4.8 miles, in addition to the 5.0 miles of preliminary borings put down in locating the dam site. The agreement prices of these borings ranged from $2.25 to $3.00 per lin. ft., the average price being $2.50.

The property has been acquired by condemnation, as provided by the special act under which the Board is operating. There is a provision by which title becomes vested in the city at the time the Commissioners of Appraisal file their oaths of office and upon the city paying one half the assessed valuation. The city became vested with the real estate, 80 acres fee, 49 acres easement, total 129 acres for the tunnel and shaft sites, on May 25, 1917, and that for the reservoir, 2 372 acres fee with 2 acres road easements, on November 24, 1917, aggregating 2 503 acres. The preliminary work of definite location and surveying, mapping and formalities of securing the property thus consumed about a year and a half from the date of the final approval of the project.

The Gilboa Dam.

Contract 203, for the Gilboa dam and appurtenances, was awarded on June 23, 1919, to the Hugh Nawn Contracting Company, Roxbury, Mass., the amount, based upon contract quantities and unit prices, being $6 819 910. The dam will be located in the town of Gilboa, Schoharie County, about four miles northeast of the Grand Gorge station of the Ulster and Delaware Railroad. This is 66 miles by rail from Kingston, and 155 from New York. The dam will be located on the present site of the village of Gilboa, which, with its population of about 300, is the only village to be obliterated.

The dam will be of two distinct types. On the east side of Schoharie Creek and in the bottom of the stream the rock is at or near the surface. On this rock foundation will be constructed an overfall masonry portion, 1 300 ft. long and 160 ft. high. The west bank is composed of a very stiff, impervious clay which extends in every direction, and the pre-glacial gorge of the stream is completely filled and deeply covered with tight and impervious

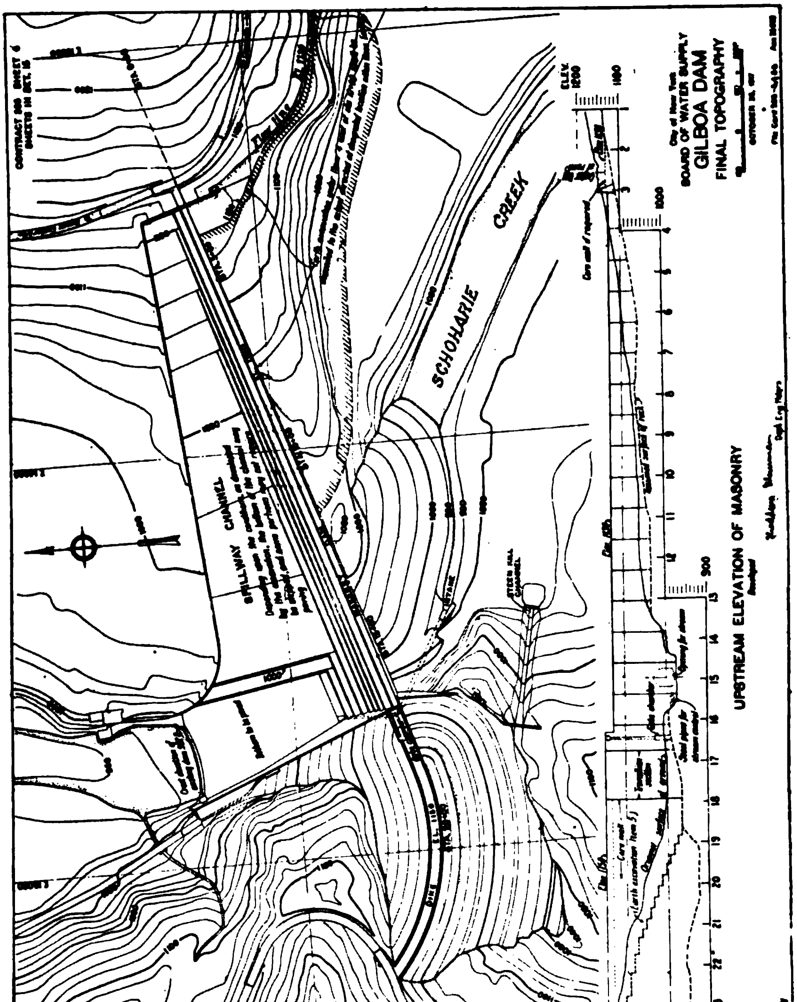

SCHOHARIE CREEK
SPILLWAY CHANNEL
UPSTREAM ELEVATION OF MASONRY
BOARD OF WATER SUPPLY
GILBOA DAM
FINAL TOPOGRAPHY

FIG. 2.

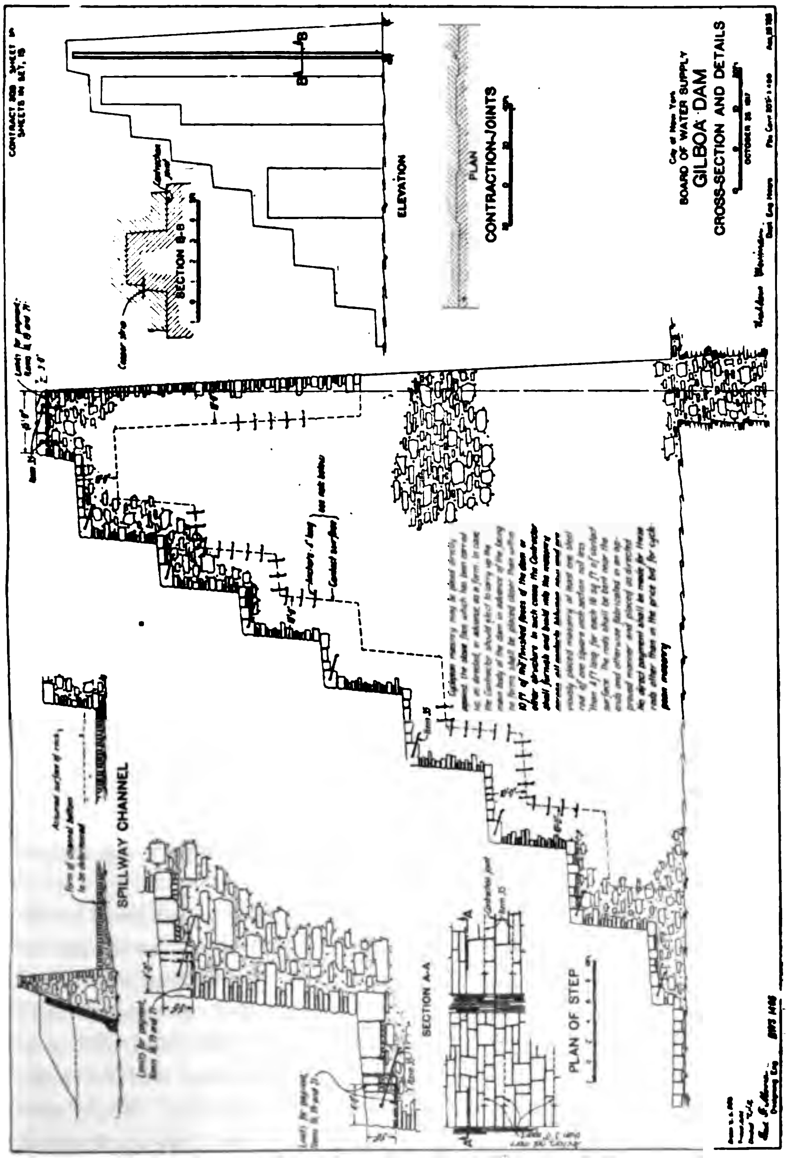

SPILLWAY CHANNEL
SECTION A-A
PLAN OF STEP
SECTION B-B
ELEVATION
PLAN
CONTRACTION-JOINTS
City of New York
BOARD OF WATER SUPPLY
GILBOA DAM
CROSS-SECTION AND DETAILS

FIG. 3.

material. For this side of the stream an earth embankment portion, 1 000 ft. long and approximately the same height as the masonry portion, will be built. At the transition section the dam will be flanked both upstream and downstream by a heavy masonry retaining wall to intercept the long slopes of the earth section.

The overfall section is designed with steps on the downstream side, for the purpose of breaking up and safely conducting the overflowing water down the face of the dam to the spillway channel below. There will be a cut-off wall about 20 ft. deep and 20 ft. wide under the foundation. Dovetailed contraction joints with a continuous vertical copper strip water stop extend across the dam from the foundation up at intervals of about 80 ft. All the masonry will be concrete, into which stones may be embedded in the sizes and proportions found practicable. All exposed surfaces are to be of selected native sandstone with mortar joints. The earth portion of the dam is of conventional design, with masonry corewall and with heavy rock paving on the upstream slope.

The spillway channel, along the toe of the dam, which will discharge waste waters into Schoharie Creek below, is about 80 ft. wide at the upper end and 300 ft. at the lower. The rock bottom slopes rather steeply and will be protected where necessary with masonry and substantial paving. The side of the channel away from the dam will be defined by a masonry retaining wall. A field model of the overfall section and channel is now being constructed by the engineers to determine certain details necessary to control the overflow.

The contract also includes the construction of about three miles of highways which must be completed before active operations on the dam can begin.

The stream-control scheme during construction, outlined in the contract, is similar to that used at Ashokan dam, involving the placing of, first, two large steel pipes over the foundation cut-off trench, and later, the construction of an arched opening through the dam 45 ft. wide by 50 ft. high, which will be filled with concrete when the dam is completed. This opening will have an appreciable bell-mouth to increase its flood capacity. Experience at Ashokan demonstrated the desirability of this increase in capacity. There is also a permanent blow-off, with 30-in. valve

in duplicate. The principal items of the contract are 396 000 cu. yd. of earth excavation, 92 500 cu. yd. of rock excavation, 617 000 cu. yd. of refilling and embanking, 436 000 cu. yd. of masonry, and 480 000 barrels of Portland cement. The contract time is sixty-six months.

The Shandaken Tunnel.

Contract 200, for the Shandaken tunnel, was awarded November 9, 1917, to the Degnon Contracting Company of New York City, for $12 138 738, based on contract quantities and unit prices. As this is an unusually long tunnel, it was considered advisable to divide the work into two parts, upon which intending bidders might submit their proposals separately; but the low bid accepted for the entire tunnel was less than the sum of the separate part bids received. The main parts of the contract comprise the intake works, the tunnel and the outlet works.

The intake works will be located about three miles north of the village of Prattsville and two miles south of the dam on the westerly side of the reservoir. They will consist of an intake channel and chamber with superstructure and intake shaft. The chamber will be built into the rock and will house eight 3-ft. by 7-ft. sluice gates set radially in the wall of the central well or extension of the intake shaft. The superstructure will have rubble walls of native bluestone, reinforced concrete floors, steel roof trusses and steel framing for the crane over the intake shaft. This building will have two wings, providing living quarters, garage, office, machine shop, and storerooms. The intake shaft will be 14 ft. in diameter, except where constricted near the top by a Venturi meter.

The tunnel extending from the intake works in a general southeasterly direction for a distance of 18 miles to the outlet works, to be located on the upper reaches of the Esopus Creek just south of the village of Allaben, will be of sufficient size and gradient to transport water from Schoharie reservoir to the upper reaches of Esopus Creek at the rate of 600 million gallons a day. The velocity of the flowing water will be 8.7 ft. per second, equal 5.9 miles per hour, acting as a grade tunnel. The tunnel will be operated intermittently at varying rates, depending on the condi-

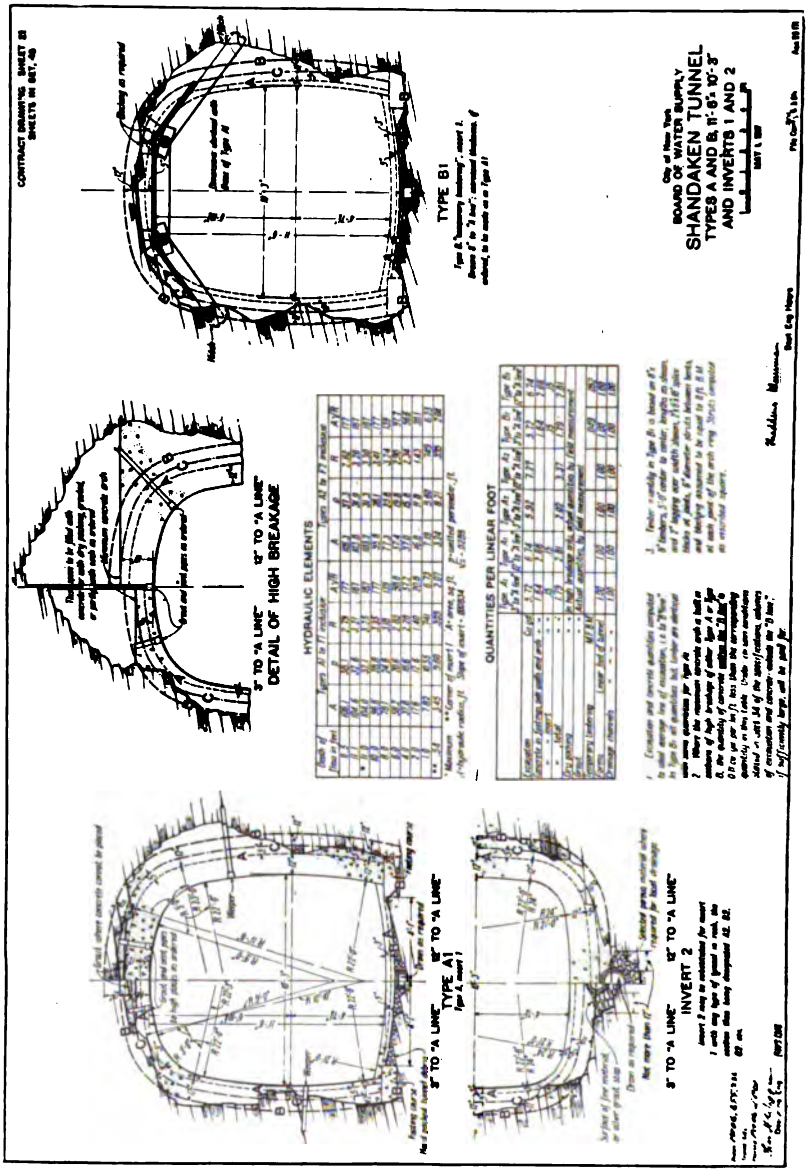

City of New York
BOARD OF WATER SUPPLY
SHANDAKEN TUNNEL
AND INVERTS 1 AND 2
TYPE B1
DETAIL OF HIGH BREAKAGE
HYDRAULIC ELEMENTS
QUANTITIES PER LINEAR FOOT
TYPE A1
INVERT 2
5" TO "A LINE"
12" TO "A LINE"

FIG. 14.

tions of stream flow and storage. The intake sill will be at elevation 1 050, and the outlet channel weir will be at elevation 969. The tunnel will be in rock of shale or sandstone, except for about 350 ft. of tunnel in earth adjoining the outlet, and will be lined throughout with concrete. The waterway section is of horseshoe shape, 11 ft. 6 in. high by 10 ft. 3 in. wide, inside dimensions; about 5.7 cu. yd. of excavation per linear foot, and the tunnel will have a uniform grade of 4.4 ft. per mile except for the northerly 3½ miles, which will be depressed in order to pass in rock of good quality beneath the gorge of the Bear Kill. There are seven intermediate shafts which will be permanent in order to provide ready access to the tunnel. The shafts will be lined with concrete and will have a diameter of 14 ft. inside. Small superstructures of native stone will cap each shaft, and guarded openings in the floor and walls of these buildings will provide for air movements in the tunnel. The aggregate depth of shafts will be 3 238 lin. ft., the maximum depth of a single shaft being 630 ft. The minimum distance between shafts is 1.3 miles, the maximum 2.7 miles. The greatest depth of cover is where the tunnel passes under the main divide of the Shandaken Mountains, where the top of the mountain is 2 200 ft. above the tunnel. Work has been going on since the award of the contract, and to July 16, 1919, about 2 800 lin. ft., or 86 per cent. of the total depth of shafts, has been excavated; and 2 560 lin. ft., or 79 per cent. of the aggregate depth of shafts, lined with concrete, the lining being placed in stretches following the excavation. Three of the shafts have reached tunnel grade, and the others, except the intake shaft, are nearing it. The maximum weekly progress of shaft excavation in each of the seven shafts has been between 27 and 42 lin. ft., and the average progress of all shafts 12 ft. per week.

The outlet works at Allaben on Esopus Creek will be located 11 miles above the Ashokan reservoir, or 16 miles above the Ashokan dam. They will consist of about 500 ft. of aqueduct of the cut-and-cover type, an outlet chamber and about 290 ft. of open outlet channel. The cut-and-cover aqueduct will be of horseshoe shape, 11 ft. 6 in. high by 10 ft. 3 in. wide. Near the lower end it becomes a reinforced concrete waterway 11 ft. 6 in. in diameter, with a fall of 16½ ft., providing a water seal for the tunnel outlet.

The outlet chamber will be an open flaring structure whose invert will slope upward to the invert, elevation 969, of the open channel. The latter will have masonry sidewalls and local stone paving. Sloping gently for 290 ft. and passing under a steel girder bridge, which will carry the highway, the channel will discharge the water from the tunnel into Esopus Creek on its way to Ashokan reservoir.

The estimated contract quantities are about 600 000 cu. yd. of rock excavation, 100 000 cu. yd. of earth excavation, 200 000 cu. yd. of concrete masonry and 445 000 barrels of Portland cement. The contract provides direct payment for medical services for the laborers and sanitary services for the camps and working locations. The shaft work has been done with individual plants at each location, but a power line is being constructed by the contractor to bring electric energy from Kingston for the tunnel work. Within seventy-eight calendar months the work underground must be completed so that the tunnel can be operated, and all work must be completed within seven years.

Highways and Miscellaneous.

Contract 202, for the grading about 7¾ miles of highways around the Schoharie reservoir, was awarded on June 13, 1919, to the Schunnemunk Construction Company, Highland Mills, N. Y., for $176 000, based on the contract quantities and unit prices.

The estimated quantities are 112 500 cu. yd. of earth and rock excavation, 7 550 cu. yd. of paving, masonry, etc., 6 500 barrels of Portland cement, and 22 000 lin. ft. of wooden guard-rail. The contract time is eighteen months.

Other Schoharie work not yet under contract will be a permanent highway bridge over Schoharie Creek below the dam, a highway bridge and approaches over the Manorkill, a tributary of the reservoir, and the clearing of the reservoir site. To finish the main aqueduct to the city, additional tubes at fourteen locations, of steel-pipe siphons, will be required.

Statistics of Ashokan, Schoharie, and Kensico Reservoirs.

	Ashokan Storage Reservoir.	Schoharie Storage Reservoir.	Kensico Emergency Reservoir.
Capacity, total	130 000 000 000 gal.	22 000 000 000 gal.	38 000 000 000 gal.
Capacity, available	128 000 000 000 gal.	20 000 00 0000 gal.	29 000 000 000 gal.
Water surface	12.8 sq. miles = 8 180 acres	1.83 sq. miles = 1 170 acres	3.5 sq. miles = 2 218 acres
Land acquired	23.8 sq. miles = 15 222 acres	3.72 sq. miles = 2 372 acres	7.0 sq. miles = 4 500 acres
Elevation of top of dam, above tide	610 ft.	1 130 ft.	370 ft.
Elevation of flow line, above tide	West Basin, 590 ft. East Basin, 587 ft.	.... 1 130 ft.	.... 355 ft.
Length of reservoir	12 miles	5 miles	4 miles
Length of shore line	40 miles	12 miles	30 miles
Length of dams and dikes	5½ miles	2 300 ft.	3 300 ft.
Main dam:			
Total length	4 650 ft.	2 300 ft.	1 825 ft.
Length of masonry portion	1 000 ft.	1 300 ft.	1 825 ft.
Height (maximum)	252 ft.	160 ft.	307 ft.
Thickness at base (maximum)	190 ft.	165 ft.	235 ft.
Thickness at top (minimum)	23 ft.	15 ft.	28 ft.
Width of reservoir:			
Maximum	3 miles	4/5 mile	3 miles
Average	1 mile	2/5 mile	1 mile
Depth of reservoir:			
Maximum	190 ft.	140 ft.	155 ft.
Average	50 ft.	58 ft.	52 ft.
Villages submerged	7	1	1
Permanent population of submerged area at beginning of work	2 000	350	500
Cemeteries removed	32	7	None
Bodies reinterred	2 800	1 330	None
Railroad relocated	11 miles	None	None
Highways discontinued	64 miles	13.6 miles	14.8 miles
Highways built	40 miles	12.4 miles	15.1 miles
Highway bridges built	10	2	4
Earth and rock excavation	2 500 000 cu. yd.	488 500 cu. yd.	1 400 000 cu. yd.
Embankment	7 300 000 cu. yd.	617 000 cu. yd.	2 010 000 cu. yd.
Masonry	900 000 cu. yd.	436 000 cu. yd.	965 000 cu. yd.
Cement	1 200 000 barrels	480 000 barrels	897 000 barrels
Maximum number of men employed	3 000	....	1 500

PROTECTING IRON AND STEEL STANDPIPES FROM CORROSION.

BY CHARLES W. SHERMAN.*

The proper maintenance of an iron or steel standpipe involves periodic painting to prevent corrosion which would weaken and ultimately destroy the structure. The protection of the exterior surface involves no particular difficulty, as it can be inspected at any time, and the coating can be replaced whenever it may appear necessary or desirable. A paint coating on the outside surface of the standpipe is subject to practically the same conditions as one on a bridge or building. The interior surface is, however, difficult to protect, being constantly in contact with water. Moreover, it can be inspected only at intervals and with some difficulty, and it is often difficult or impossible to leave the standpipe empty for a sufficiently long period to clean and paint the surface in the most desirable way.

The durability of a protective coating on the interior surface of a standpipe is dependent not only on the qualities of the coating itself, but also on the character of the plates to which the coating is applied (whether wrought iron or steel); the cleanness, dryness, and temperature of the surface when the coating is applied; the character of workmanship; the character of the water; the amount of ice formation in winter; fluctuations in the water level, etc.

Data relative to the conditions existing when coatings were applied have comparatively seldom been made a matter of record. Indeed, it is more often than not the case that the kind of paint and the quantity used are not recorded. Consequently, the amount of definite information obtainable, even by extended inquiry, is comparatively limited, and much of it is of doubtful value.

* Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

In an attempt to bring together such information as may be obtainable, relative to actual experience with standpipe paints, Messrs. Metcalf & Eddy sent inquiries to water works in the northern and eastern parts of the United States where iron or steel standpipes are in use, requesting information as to the dates of painting, kind of paint used, preparation of the surface for painting, and other significant data. In general, the water works superintendents were generous with their responses, which were received during the winter of 1916–17, but in a disappointingly large number of cases the responses were, in effect, — "The writer has been here but a short time. The former superintendent left no records, and I do not know what paint was used or when it was applied."

The accompanying tabulation contains the significant data received in response to this inquiry, together with some information available from other sources. Unfortunately, it has not been practicable to bring the information down to date before presenting this paper. The returns, however, represent the conditions existing up to the time the United States entered the war, and it is probably fair to assume that very little in the way of standpipe maintenance has been done during the period of the war.

The data tabulated are not susceptible of being summarized or averaged. In a few cases it will be noted that the standpipe has not been painted since erection. There are doubtless cases in which the quality of the water is such that it protects rather than corrodes the metal. Such cases are, however, rare, and the experience tabulated seems to indicate that as a rule an iron or steel standpipe should be thoroughly cleaned and painted inside, at least as often as once in four or five years. Perhaps, however, if the cleaning were as thorough as would be accomplished by means of the sand blast, and if a protective coating were then properly applied, the interval between paintings could be materially extended.

In response to the letter of inquiry, Mr. A. H. Kneen, of Philadelphia, sent a report entitled, "Painting the Inside of Standpipes," which is submitted herewith as an appendix, and which contains the best and most complete comparative data which have come to the writer's attention.

Mr. Kneen painted two standpipes with vertical stripes of different kinds of paint, and observed the conditions after two or three years of service. The only paints which gave reasonably good service were a red oxide of iron paint, and red lead.

Most of the paints used were undoubtedly proprietary articles, and although one red oxide of iron paint showed "good" or "very good" results, several others characterized the same way in his tabulation gave "bad" or "very bad" results. It is to be noted, too, that red lead when used was employed only in the first coat, yet the results were characterized as "good" or "very good." It is not impossible, therefore, that two or three coats of red lead would have shown better protection than any of the other paints.

The engineers of the Metropolitan Water Works have adopted the policy of cleaning the steel by sand blast, and applying three coats of red lead to the interior surface of their steel standpipes. The following quotation from the fifteenth annual report of the Metropolitan Water and Sewerage Board describes the cleaning and painting of the Bellevue Hill standpipe:

"On March 25 the tank was taken out of service and drained, and the work of sand blasting and painting the steel was begun March 30 by the W. L. Waples Company of Boston, subcontractor for this work. The plant used consisted at first of a twenty horse-power gasoline-engine-driven air compressor, a compressed air reservoir, two lines of air hose and two nozzles. Sand blasting was stopped in the latter part of the afternoon of each day, and the cleaned surfaces were painted before rusting commenced. The force employed included 1 foreman, 2 painters, who also did sand blasting, and 1 helper. This force could sand blast and paint an area of about 330 sq. ft. per day. Later, in order to increase the rate of progress, a second compressor, operated by an automobile engine, was installed on April 19. The entire inside and outside surface of the tank, having an area of 35 650 sq. ft., was sand blasted and painted. Work was completed June 14, with the exception of the third coat on the outside, which has been deferred until after the masonry tower which encloses the tank is completed. All painting materials were furnished by the department, but were mixed by the contractor under the direction of the engineer. For the inside of the tank, National Lead Company's red lead in oil paste, litharge, and Spencer-Kellogg & Son's boiled linseed oil, were used; the first coat natural color,

the second and third coats tinted with lampblack in oil. For the outside of the tank, red lead paste, raw linseed oil, and drier were used for the first coat, and for the second coat white lead, raw linseed oil, turpentine, and drier tinted with lampblack were used. One gallon of red lead paint was sufficient to cover 700 sq. ft. of surface with one coat. The subcontractor's price for sand blasting and painting the tank was $1 600. . . ."

The writer inclines to the opinion that the method just quoted represents the best practice of the present time. He would put especial emphasis on the thorough cleaning of the metal, and the *immediate* application of the paint to the cleaned metal before the latter has cooled and moisture has condensed upon it.

The following quotation is pertinent in this connection:

"Every specification for painting bristles with clauses prescribing what shall or shall not be done, and still the fact remains that there are more failures than even indifferent successes, especially on work painted at the shops before shipment. The causes for the irregular and indifferent results are not difficult to ascertain. They are the improper application of the paint to dirty, greasy, moist or chilled, rusty or mill-scaled surfaces. No marked improvement in these uncertain results can be had until the same importance is attached to the 'paint question,' not only on paper, but in the actual supervision of the painting in all of its stages, as is given to the minutest construction details."*

With regard to the coating to be applied to the metal after cleaning, it appears probable that not only red lead, but several of the graphite and red-oxide-of-iron paints, and perhaps certain enamel-like coatings, will give satisfactory protection. From such information as he has, the writer believes red lead to be the best. Wood, in "Rustless Coatings," says, —

"The protective qualities of a well-oxidized pure red lead and a pure oil paint, properly applied to any structure under any exposure, except to the action of hydric-sulphide gas, cannot be gainsaid."

It has been used for many years for painting the bottoms of steel and iron ships, and has given the best satisfaction of any paint used for that purpose. No other substance has been put to such severe trial and shown so good results; but unfortunately the

* "Rustless Coatings," by M. P. Wood. (New York, John Wiley & Sons, 1904.)

use on standpipes has been comparatively limited, — probably because of a lurking, though unfounded, fear of lead poisoning if the water remains in contact with red lead paint.

It is obviously unfortunate that the data available are so fragmentary and inconclusive. It is to be hoped that the superintendents having charge of iron and steel standpipes will realize the necessity for more definite information and will make careful record of all the conditions affecting the durability of standpipe coatings, and that at some future time it may be possible to bring the data together and draw positive conclusions from them.

APPENDIX.

Painting the Inside of Standpipes.*

To obtain better information as to a suitable paint for protecting iron under water, the writer decided to paint the inside of a standpipe with different paints, for experimental purposes.

The first samples were applied in August, 1909, the iron being carefully cleaned with wire brushes, and loose scale chipped to clean iron. The results of our experiments to date may be of interest to water works having standpipes and towers, and the results that we have obtained to date are tabulated herein.

Our experiments have been applied particularly to the inside of the tank, as we have found that the outside can be protected by a good lead, iron oxide or graphite paint, which, if of proper quality and properly applied, will protect the iron for at least five years, unless subject to unusual conditions. Usually the appearance of the outside will call for painting before the necessity.

TABLE 1.

Tank 40 ft. in diameter by 50 ft. in height. Samples about 25 ft. in width by 50 ft. in height.

	Condition. Date of Inspection.	
Kind of Paint. Two Coats. Date applied, August, 1909.	Tank Half Full of Water, April 27, 1911.	Tank Empty, September, 1912.
1. Iron oxide	Good.	Fair.
2. Iron oxide	Bad.	Bad.
3. Graphite — black	Bad.	Bad.
4. Asphaltum — black	Very bad.	Very bad.
5. Portland cement (brushed on)	Very bad.	Very bad.

* By A. H. Kneen, Engineer, 112 No. Broad Street, Philadelphia.

In 1910 a smaller tank than the first one used for experiments was erected, and this was painted on the inside with different paints, and is still being used for experimental purposes as it is more accessible than the first.

The kinds of paint applied to the two tanks, and the results found by inspection, are listed in Tables 1 to 4 — Tables 1 and 2 covering the first tank, and Tables 3 and 4 covering the second tank. The manufacturers of the various paints used have been omitted.

TABLE 2.

Same tank as Table 1. Samples about 8 ft. in width by 50 ft. in height.

Date applied, September, 1912.	Date of Inspection. Tank Half Full, May, 1914.	Tank Empty, May, 1916.
1. Oxide of iron — red	Very good.	Very good (best).
2. Oxide of iron — black	Very bad.	Fair.
3. Tar base — black	Very bad.	Very bad.
4. Oxide of iron — red	Fair.	Bad.
5. Oxide of iron — red	Fair.	Bad.
6. Pitch — black	Very bad.	Very bad.
7. Graphite — carbon	Very bad.	Fair.
8. Graphite — carbon	Very bad.	Fair.
9. Oxide of iron — red	Fair.	Good.
10. Car. coating — black	Good.	Very bad.
11. Oxide of iron — red	Fair.	Fair.
12. Oxide of iron — red	Fair.	Bad.
13. Oxide of iron — red	Very bad.	Bad.
14. Tar — black	Very bad.	Very bad.
15. Red lead, first coat; metallic brown, second coat	Good.	Good.
16. Flexible tank oxide of iron—red	Good.	Good.

Repainted May, 1916, with iron oxide paint, and experiments discontinued.

TABLE 3.

Tank 30 ft. in diameter by 39 ft. in height. Samples about 16 ft. wide and 39 ft. high. Painted May, 1910.

Paint — Two Coats.	Condition. Date of Inspection. Tank Half Full of Water, February, 1911.	Tank Empty, September, 1914.
1. Graphite	Bad.	Bad.
2. Rubber paint	Bad.	Bad.
3. Oxide of iron — red	Good.	Very good.
4. Oxide of iron — red	Bad.	Bad.
5. Red lead (1), metallic brown (2)	Fair.	Good.
6. Oxide of iron — red	Good.	Bad.

TABLE 4.

Same tank as Table 3, repainted on inside, September, 1914. Twelve samples about 8 ft. by 39 ft. in height.

Kind of Paint — Two Coats.	Inspected December 26, 1916. Tank Half Full of Water.
1. Oxide of iron — red	Good.
2. Pitch — black	Bad.
3. Oxide of iron — red	Bad.
4. Asphalt and Portland cement	Bad.
5. Red lead, first coat; metallic brown, second coat — brown	Very good.
6. Red lead lute, first coat; metallic, second coat, brown	Bad.
7. Oxide of iron — red	Bad.
8. Tank paint, pitch — black	Bad.
9. Tank paint, oxide of iron — red	Bad.
10. Roof coating — pitch — black	Bad.
11. Tank paint — oxide of iron — red	Good.
12. Sticktite No. 3, pitch (black)	Bad.

Samples marked "Good" and "Very good" had comparatively few tubercles on surface and no scaling or blistering. Samples marked "Fair" had more tubercles and some scaling and blistering. In samples marked "Bad," the surface was fairly well covered with tubercles and some blistering and separations had taken place. In samples marked "Very bad," the surface was generally covered with tubercles and the paint badly scaled and very badly blistered. In the painting of September, 1914, the red lead and metallic brown paint used was mixed on the ground by our chief painter and the best quality of everything was used.

Cost.

Labor cost, which covers cleaning and the application of two coats of paint, is usually less than $20.00 per thousand square feet. The amount of paint required for two coats on the inside has averaged 5½ gal. per thousand square feet, or one gallon of paint covers about 180 sq. ft. of iron with two coats. Assuming that the paint costs $1.50 per gallon, the cost of paint for two coats would be $8.25 per thousand sq. ft., which, added to the labor cost, makes the total cost $28.25 per thousand square feet.

The iron can be prepared for the paint by the sand blast, and other protective coatings can be secured with five-year guarantees, but the expense of such cleaning and such application at the prices quoted is, in our judgment, too great to warrant the expenditure.

Under the writer's supervision, we have had the inside of fifteen standpipes painted and repainted in the past seven years, the combined area of which is over 112 000 sq. ft., and the results obtained are similar to those

obtained in the experimental tanks. Our conclusion to date is that paints having pitch or asphalt for a base, applied in this manner, are not suitable for iron in contact with water, but that two-coat work with a good quality of iron oxide paint or a paint with a good red lead base for the first coat, and an iron oxide paint for the second coat, if the iron is properly cleaned and the paint is properly applied, will protect the iron in contact with water for at least four years, unless the water is of unusual quality or the conditions are different than usually met with in water-works practice.

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DISCUSSION.

MR. FRANK L. FULLER. I do not remember that Mr. Sherman gave us anything in regard to the cost of this sand blasting operation.

MR. SHERMAN. The cost of the whole operation is given in the Metropolitan Report, but I can't give you the cost of the individual items because I haven't the information for it.

I will say, Mr. President, that wherever data are given for the cost of painting, it is for painting the interior surface. Perhaps I did not make it as clear as I should at the beginning that I confined my paper to the painting of the interior. The exterior I am not particularly interested in. Any house painter can paint the outside of a standpipe, and, anyway, you will know if it does

not last. But painting the inside is another matter. In many cases the figures given cover the inside and outside, but I think I have made that clear in my table. Unfortunately, it was not always possible to tell what the cost of painting the inside was. As to how thorough the cleaning was, you will have to draw your own inference. Nobody but the man who did it probably knows how thorough the cleaning was.

Mr. Rudolph Hering. Mr. President, I should like to say a few words in reference to this subject, although it is not directly the subject of the paper, but it is one which I have always thought should be considered.

Many years ago I was in the Rocky Mountains, and we noticed that our hair stood on end, and very soon we found out that electricity was passing up through the mountain and escaping, and we were right in the current.

Now, we know that that happens. We know that, for instance, a lonesome tree on a plateau is easily struck by lightning, and if you examine that tree you will find a current of electricity going up most any time. I stood on one of these standpipes at one time to see whether there was an electric current going up there. I took off my hat, as did also my friend, and sure enough our hair stood up on end. That shows that an electric current passes up a great many of these standpipes.

We know from our water pipes in the ground how much we have suffered from electric currents passing through those water pipes. They have been corroded. And it struck me, although it is out of my line, that in the construction of standpipes this question of electricity should be considered, and I was waiting for some remarks on that in Mr. Sherman's paper, so I thought I would relate this old story.

It seems to me that if we could, in addition to the paint, which of course is necessary, find some way by covering the top, and also the bottom, with some insulating material, we could prevent an electric current very frequently, if not always, from passing through that standpipe, and we might increase its life. I merely throw that out as a suggestion.

Mr. Francis T. Kemble. Mr. Chairman, my experience backs up the previous speaker's experience as to painting the outside of the tanks.

I might say that we have two tanks at New Rochelle, and I have tried employing the same men that we have had painting the inside — real steel workers — on the outside, and at other times I have tried house painters and got just as good results at about one third the cost. On the inside we use red lead paint. The first time I tried cleaning this pipe was about twelve years ago, and there were some pretty bad pittings. At that time we pumped until about midnight and then shut down, and then the next morning the tank would always be drawn down to about the same point, and just above that point was considerable pitting, pretty deep. All that was cleaned out with wire brushes and painted with red lead. About three years afterwards, when again painted, we found nearly all those pittings were in good shape. That red lead took right hold. But a few of them had to be cleaned. We tried doing that every four years, but can't get the labor nowadays.

Mr. Frank A. Barbour. I note by this table that the standpipe at Reading, Mass., was covered with one coat of "Government waterproof" some years ago. I should like to have Mr. Bancroft tell us what its condition is at the present time.

Mr. Lewis M. Bancroft. Mr. President, I can't say anything about the present condition of that standpipe, because we have not opened it. I have not seen the inside of the standpipe since that coating was put on.

Mr. A. P. Folwell. I notice one of the standpipes here was built over thirty years ago and has never been painted. I was wondering whether Mr. Sherman could tell us anything about that, and what condition the standpipe is in if it has stood thirty years without any paint on it.

Mr. Sherman. Which one is that? I know there are several there that have been reported as not having been painted.

Mr. Folwell. That is Norwood, Ohio.

Mr. Sherman. I do not know anything about that.

Mr. Folwell. It was built in 1884 and has not been painted, — "Paint not needed."

Mr. Sherman. There are two or three cases where they have reported "Paint not needed." I do not know whether they know what they are talking about or not.

MR. J. M. DIVEN. That thirty-year old standpipe was probably wrought iron and not steel.

MR. FOLWELL. It was iron.

MR. KEMBLE. There is one little experience we had in connection with our standpipe which may be of interest. This is a tank 60 by 60. It has a 6-in. blow-off on it, and it has a box on the outside. The box had got in bad shape. The box got full of water and it froze and cracked and threatened to let go. We had had some experience before with the tank overflowing and slacking a lot of lime down below which we had to pay for.

The way we met the situation in this case is that we put a trap in that 6-in. pipe and fed a lot of copper wire, and the fellows fished for it up at the top with an iron hook on the end of a line, probably about twenty minutes, patiently trying, and they managed to catch it. They pulled that up and fastened the wire, which is about as heavy as we could get through well, to a plug that had a bore right through it with an eye in each end, and we attached this wire at the small end of the plug. At the other end we had two eyes, and managed to bring that thing right down in the pipe. Then we plugged it nearly tight, and cut the pipe, put on a new gate, and then took a sapling and used a tackle upon the gate and jammed the plug right out of place and got through without any trouble.

MR. JOHN CULLEN. There are four tanks in Woonsocket; one is concrete, the other three are steel or iron. The first one was a wrought-iron tank. It has been there thirty-five years, or a little more. The tank is in good condition, or was the last time examined, which was five years ago. I don't know about it since. It has not been painted because we cannot get along without it. We can't supply enough water to have it drained off. The other two tanks, which are steel, I expect are much more efficient than the first one is.

MR. H. T. GIDLEY. We have had our standpipe at Fairhaven painted inside — wire-brushed inside and then painted with a hot coating of rubber-elastic nature, and it has been painted five years on the inside, and was examined lately and seems in as good condition, practically, as when it was painted. The outside was painted with lead and oil, and although in fair condition it

rather needed painting again, so that we painted it on the outside this fall with the same preparation that we painted the inside with, only it was a little thinner. We put on two coats.

I understand that Portland had two tanks painted by the same man that painted ours this fall. If there is anybody here from Portland I should like to hear from them about it.

President Killam. Mr. Sherman, can you give us any information about cleaning standpipes with gasoline?

Mr. Sherman. Not a thing, Mr. President. I have heard it mentioned, but I don't know anything about it.

President Killam. I think we have all heard more or less about cleaning tanks with gasoline. Is there anybody here who has had experience in that?

Mr. Kemble. Answering the gentleman from Woonsocket, speaking of not being able to spare his tank, I might say that each time we inspect our tank and empty it we pump right into the mains through a relief valve that connects with one of the reservoirs. You can throw your tank out of service entirely. We have tried that about four times without any trouble.

Mr. Frank L. Fuller. Mr. President, it seems to me that these standpipes are one of the most generally neglected parts of the water-works system. I remember seeing a tank — I forget just where it was, Randolph or Holbrook, or down that way somewhere — that was in a horrible condition. I think it had not been used for a while, but it looked hardly safe to put water into. The rivets were badly corroded, and the plates also somewhat on the inside. And I think there was a ladder on the side, which was all gone except at the bottom of the tank. It seemed to me that some effort ought to be made every three or four years to see that the tank is in good condition, for it is, of course, a very essential part of the system. If the tank becomes disabled so that you can't pump into it, you are in pretty bad shape.

I did not notice whether Mr. Sherman said anything about ladders on the inside of the tank. It has always seemed to me that they were a pretty poor thing to have, that it was a great deal better to have one ladder on the outside and let the inside ladder go. In the old days it used to be very common to have riser pipes and ladders on the inside, which the ice was apt to

get attached to, and as it rose and fell cause damage by tearing them away from the shell, producing leaks. I think those have been to a large extent given up.

President Killam. In the Metropolitan District in Boston we have spent considerable time on experimental work in connection with the standpipes. The best paint that we have been able to find was the Dutch Boy red lead. The Dutch Boy red lead people will tell you that litharge should not be added to their paint. But we do not agree with them. We add litharge to harden the paint when we apply it.

We have tried painting standpipes by contractors, the contractors furnishing the paint under specifications, but the most satisfactory way has been to furnish the materials ourselves and let the contractors do the work. It may require a little more material for the contractor to put it on this way, but it pays in the long run.

The cleaning of the old standpipes in every case has been by wire brushes, and the pits thoroughly cleaned, and then the first coat of red lead mixed with the best linseed oil — which at present is hard to find, but we get the best on the market. It costs about three quarters of the labor for cleaning and one quarter for painting the interior of the standpipe, according to our experience.

For the second coat we have put on the Dutch Boy red lead with a little lampblack. Now, that is simply to tone down the red lead so that we can watch the contractor. In that way we know where he has painted and where he has not. For the third coat we put considerable lampblack in, and that is to watch the contractor and also to satisfy the general public. We have found that the general public is a little suspicious of red lead paint, whereas if you tone it down so that it makes a maroon, or something along that line, they do not think so much about it. In fact, at the present time we are mixing our green paint for our steel work from Dutch Boy red lead, using Prussian blue, and so forth.

Another factor which has entered into the painting of standpipes in the Metropolitan District is the ice. While all our tanks are covered, we have more or less ice, especially during a winter the same as two years ago, and the action of ice on the side of the tank not only keeps the tubercles from forming but it

also has a tendency to take the paint off. That was the trouble with the Gilsonite paint which we put on over the red lead in the standpipe at Arlington. The action of the ice on the Gilsonite paint took it entirely off the side of the standpipe, and we found it in the bottom.

In connection with the red lead, three coats of straight red lead, toned down with lampblack or something of that kind, we find wear at least twice as long as red lead covered with some other kind of paint.

On the outside of the standpipe it does not matter so much, although we use the red lead first and then some other paint over that. That is something we can get at at any time.

The tubercles which form on the inside of standpipes seem to be all below the low water line — at least, those of any size. The pits are the deepest at 10 or 15 ft. from the bottom. There has been very little rust formed on the sides, and some on the bottom of the standpipes, but that is easily cleaned.

Mr. E. M. Nichols. I understand in the preservation of metal surfaces the first thing that is necessary is to remove any oxide that may have formed before you apply the coating. The next thing is to apply a coating which will not oxidize, — at least, not very easily.

In mixing red lead or oxide of iron with something else, either boiled or raw linseed oil, it was always my impression that the oil was the biggest part of the whole proposition, while the oxide or lead probably was added to it to give it a little more value; that the oil gave the red lead enough elasticity so that it would not crack, — both of them were a fair preventive against oxidation.

Now, why should red lead be the super article? It is simply because it is a substance of the iron itself. We all know unless you apply the thing properly it does not work. If you have a rusty piece of iron, it will rust through sooner or later.

The whole thing lies in doing it in a proper manner. One of the greatest troubles we have in keeping up our reputation as contractors is the slackness of the men.

Mr. J. F. Sullivan. Mr. President, I should like to get some information from Mr. Sherman. I should like to ask if he has had any experience in using the gun in painting standpipes. At the

present time in Chicopee we have probably one of the largest standpipes in New England, a standpipe 70 ft. in diameter by 130 ft., of iron, holding 1 900 000 gal. of water.

We have three standpipes. The old one is made out of wrought iron, erected twenty-three years, and it has only been painted twice in the twenty-three years. We could not paint it on account of not having sufficient capacity; our supply was too small.

MR. SHERMAN. Do you mean a thin coating of cement applied with the cement gun? Is that the idea?

MR. SULLIVAN. Yes.

MR. SHERMAN. No, I have never seen or known of such a thing. I have known of cement washes being used, — cement applied with a whitewash brush.

MR. T. R. KENDALL. May I ask if Mr. Sherman knows where there has been a gun used for spraying paint. I understand some manufacturer put out a certain kind of nozzle which could be used for spraying paint.

MR. SHERMAN. I do not know whether that has been done or not. The returns which we have received do not indicate the method of applying the paint.

MR. FRANK J. GIFFORD. In answer to the previous speaker I would say that in 1908 the Fall River standpipes were sandblasted and the paint put on with compressed air, and it seemed to be as satisfactory as with brushes, — perhaps more so. The result was the same; the next year the paint was all at the bottom of the pipe anyway. And that was true with the brushes.

In 1912 they erected a new pipe of steel and that paint was put on with compressed air, but I have never seen the steel tank opened since that time. I left there in 1915. But I think since that time the work has all been done by hand; why, I do not know.

PRESIDENT KILLAM. In regard to the cement wash, I might say that we experimented with that and found it was satisfactory except for the ice. The movement of the ice took off all the cement wash we put on.

SOME DETAILS OF WATER-WASTE PREVENTION SURVEYS.

BY PAUL LANHAM.*

Systems of water-waste prevention surveys as applied in the various cities and by the private companies engaged in that class of work are basically the same. That is, the old Deacon System, of English origin, with its division of the distributing mains into districts and the more or less complete analysis of the total flow, forms the foundation upon which have been constructed the somewhat elaborate and thorough detailed systems of the present day. Two branches of work naturally form the complete system. First must be determined the necessity for the surveys as indicated by the total consumption and per-capita data for the whole plant. This must be divided and separate determination made as to which sections or districts of the city are in condition demanding attention. After this, of course, follow the detailed surveys within these sections by which the actual location and causes of the abnormal or wasteful conditions are determined.

The first and probably most important step in starting a water survey of a city-distribution system is the proper division of the mains into permanent districts. This necessitates a thorough study of the general layout and some knowledge of the direction and rates of flow in the different trunk mains. These latter facts may be easily determined by using portable Pitot tube apparatus at various points. In selecting boundaries for the various permanent districts it must be borne in mind that measurable velocities are necessary at the proposed district measuring points, that valve closures must be made at neutral or nearly neutral flow points to avoid serious interference with pressure and supply, that subsequent work makes the segregation of like consumers in the same district not only desirable but almost necessary, that ample capacity must be provided in mains feeding the district when

* Engineer in charge of Waste Prevention, Water Department, Washington, D. C.

other mains are closed off during the measuring periods, and that the districts must be of such size as to permit a complete detailed survey within a period of one or two months to avoid confusion of data due to changes of season while the work is in progress.

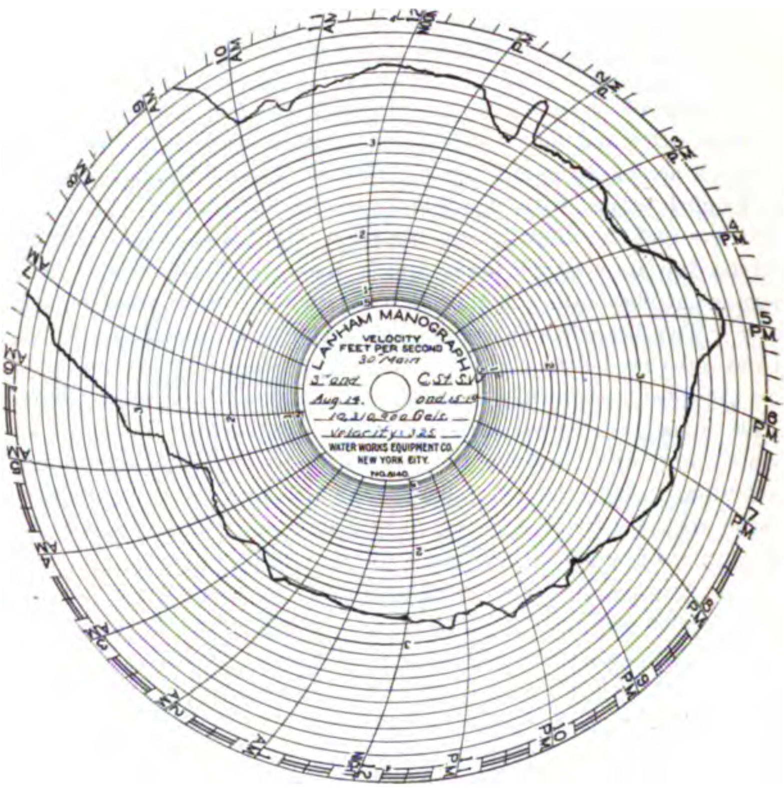

FIG. 1. TYPICAL FLOW CHART TAKEN ON 30-IN. MAIN SUPPLYING PERMANENT WATER SURVEY DISTRICT.

Note high night rate of flow into residential territory.

These points cannot of course be literally carried out in all cases. High- and low-service areas interfere; some sections have natural boundaries which must be followed, regardless of the dictates of the system; and intermixtures of factories with residences in

many cases produce undesirable conditions. Permanent boundaries, however, must be established as near as possible in conformation with the plan, and must thereafter be maintained per-

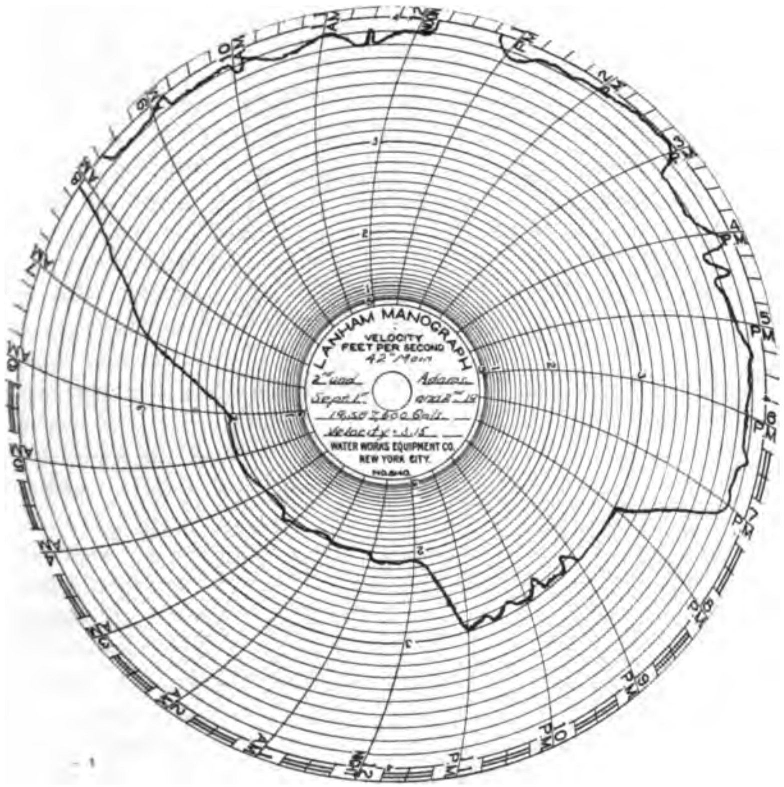

FIG. 2. TYPICAL FLOW CHART TAKEN ON 42-IN. MAIN SUPPLYING LARGE WATER SERVICE AREA.

Note peak loads occurring at 8.00 A.M. and during noon hour. Peak load at noon is an unusual occurrence. Note also rapid decline in rate of consumption after 7.00 P.M. and again at 11.00 P.M.

manently to avoid rendering useless for comparative purposes data previously secured.

Measurement of district flow should be made at as frequent intervals as possible. It would be ideal to maintain permanent recording instruments at the measuring points and keep constant

record of the flow condition. This is impractical because of the extra fire hazard and other risks involved in maintaining a great number of closed valves throughout the system. From four to six measurements of at least seven days' duration should be made if possible of the flow into each district each year. Portable recording Pitot apparatus, which *must* be used upon the detailed flow analysis within each district, is ideally adapted to these measurements, and its use for both purposes simplifies the equipment considerably. These measurements give mean daily consumption, — maximum, minimum, and night rates of flow. Population count made by the inspectors while making the detailed surveys within the districts permit the district per-capita rates to be determined. The per-capita rate and the ratio of the night rate to the mean daily rate of flow are excellent indices of the condition of the district. Of course consideration must be given to the character of the consumption when reaching conclusions based upon these figures. To facilitate this, a census of buildings is also taken during the progress of the detailed surveys, and these data, together with all other, must be recorded permanently for future reference.

Most interesting facts are frequently brought out by study of the flow charts taken upon the various districts, and their value is limited only by the intelligence of the investigator. Cases on record show districts where the night rate of flow exceeds the rate during the daytime; others show a ratio of night rate to mean daily rate, varying from zero to 100 per cent. Charts frequently show abnormally abrupt changes in the flow rate, excessive peak load, indicating over-taxation of certain mains, and many other facts which have their definite causes and reveal, upon study, all the secrets of the distribution system. Extreme variation in conditions will occur, due to variation in usage in industrial plants, season changes, and other causes, so that the data obtained must if possible be compared with previous data obtained under like conditions to determine their full import. A comparison of conditions immediately before and after a detailed survey is particularly interesting and valuable, and the dates of measurements may advantageously be selected to permit this.

In a number of cities different water-service areas, supplied

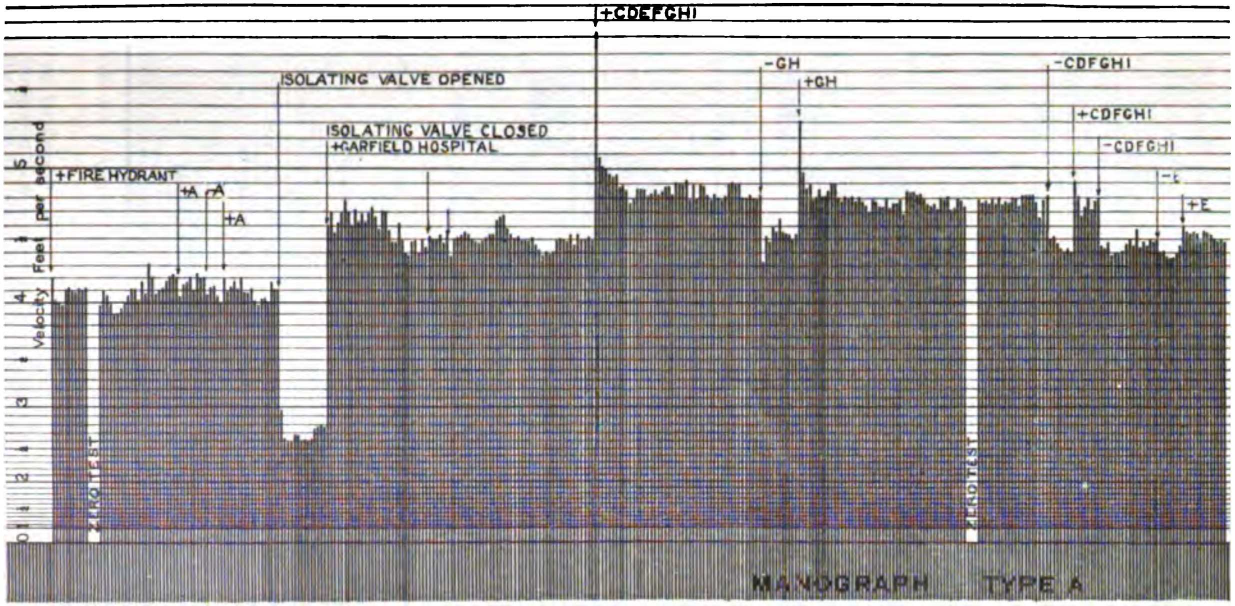

FIG. 3. CHART OF NIGHT SUBDIVISION TEST.

Note fluctuation occurring throughout the test in spite of the fact that the chart was taken on a main supplying residential section after midnight. Repetition of tests and careful computation is necessary to detect differences in rate due to small flows. Chart illustrates method of testing rate of flow into important institution (Garfield Hospital) without interrupting supply.

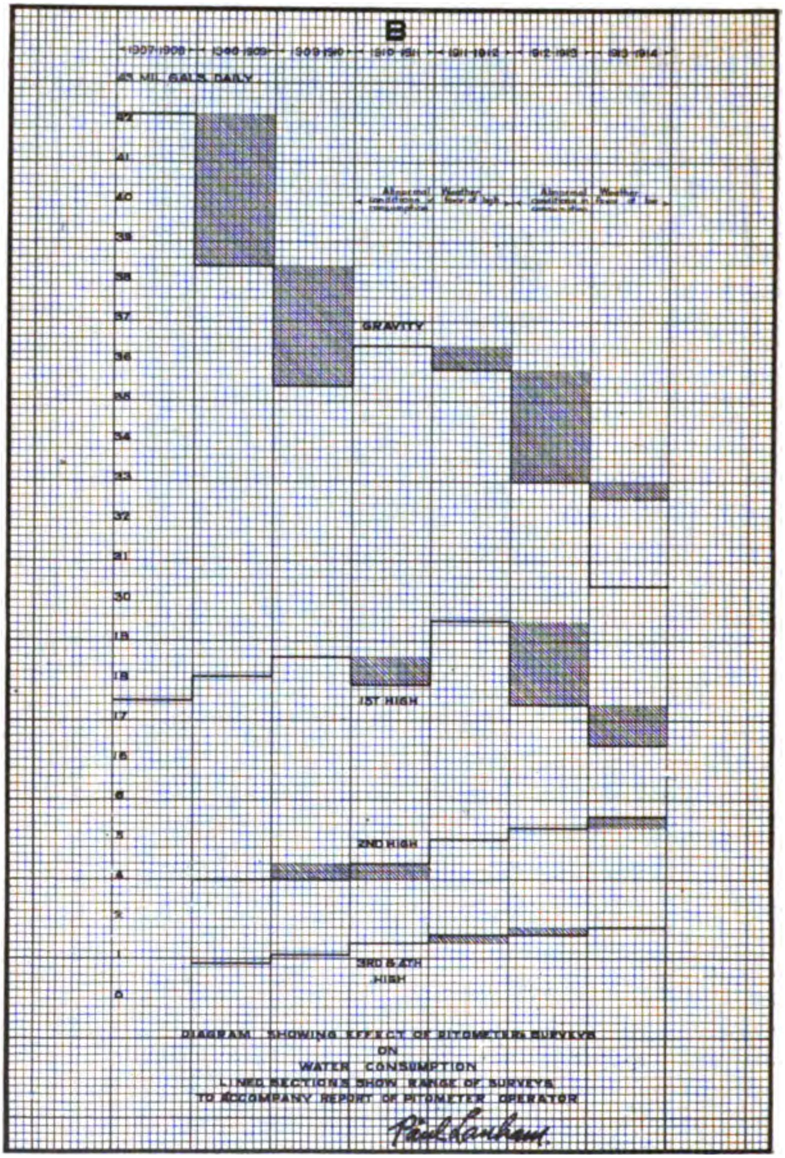

FIG. 4. ILLUSTRATION OF EFFECT OF WATER SURVEYS ON WATER CONSUMPTION.

Note invariable decrease coinciding with surveys as compared to increases at other times. Water consumption in these sections was increasing substantially each year previous to 1906, at which time the water surveys were started.

directly by individual pumps or by trunk lines where Venturi meters have been installed, constitute natural permanent districts which can be observed at all times, either by inspection of the pumping records or the Venturi charts. In many cases these natural districts are too large to be properly treated as permanent survey districts, but they form convenient units for checking total figures obtained by consolidating the data secured upon the permanent districts within their limits. Such data as mean daily consumption, per-capita consumption, and night rate of flow for the entire city should be plotted constantly as a matter of general interest and value. These figures are usually obtainable from pumping station or filtration plant reports. They form the measure of the effectiveness of the surveys and are indisputable.

Detailed surveys within the permanent districts, made for the purpose of *actually* locating and weeding out the wastes and leaks from the legitimate consumption, follow a well-defined basic system also, but the degree of thoroughness and success depends greatly upon the limitations of the pipe system in the matter of valves and stopcocks, and the ability of the operators. Measuring points having been established throughout the permanent district under survey, the portable recording Pitot apparatus is moved from place to place as the work progresses, and each section of main is given close examination. Small temporary test districts are isolated after eleven o'clock at night and the total rate of flow into them observed and recorded on the Pitot chart. Work of testing and inspecting is continued through the night until about four o'clock A.M., when it is found that the rate of flow becomes unsteady and interferes with the tests. Tests are made at this time because legitimate consumption is then at a minimum, while leaks and wastes will still be running at full head. In residential sections the rate during these hours is practically one hundred per cent. illegitimate.

The method of test consists simply of measuring the rate of flow into a limited number of squares and noting either the increase or decrease in this rate caused by altering the number of squares included in the test districts; by "squares" being meant each section of main in a given street lying between adjacent intersecting streets. In most cities, valves are placed at these points.

Of course the location of valves really determines the extent of the main included in each separate test.

To go into detail, assuming a rate of flow of 100 000 gal. per

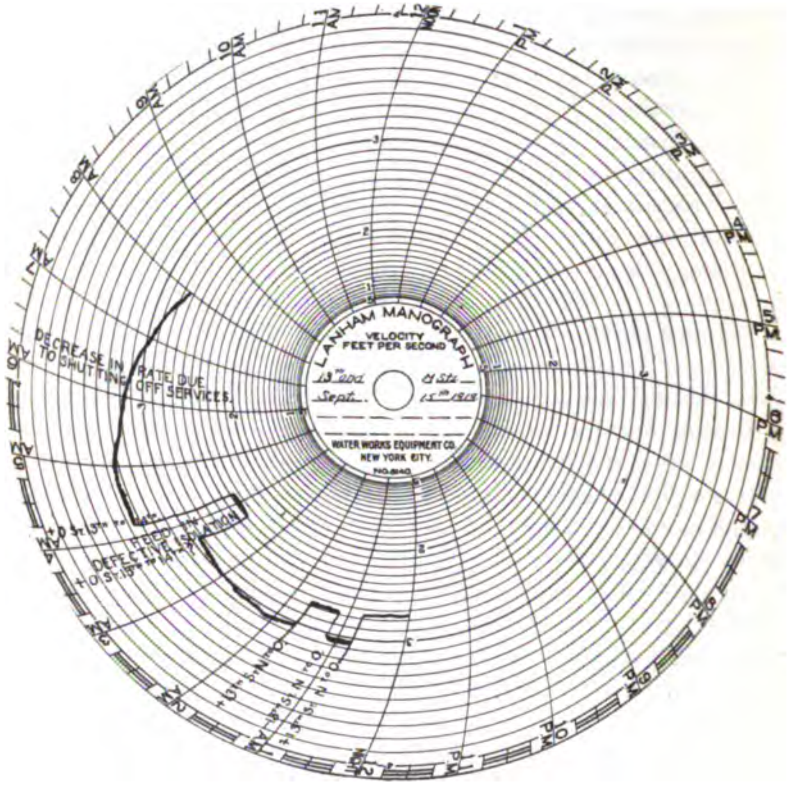

FIG. 5. TYPICAL CHART OF NIGHT SUBDIVISION TEST.

Note abrupt changes in flow rate coincident with valve operation. Note the momentary high rate coinciding with each valve opening, due to drainage from main while shut off preceding the test. In general this indicates a tight shut-off for the square and verifies the existence of a substantial flow.

day, for instance, in a test district of two squares, the rate of flow increasing to 110 000 gal. upon the addition of another square indicates of course that the rate of flow into this additional square is 10 000 gal. daily, or the difference between the rates before and after its addition. Reversing the process, the rate would of

course drop from 110 000 gal. to 100 000 gal., if the square is excluded from the test district. Both methods of testing are utilized, as conditions require. The method of adding squares is preferable, as it keeps the size of the district under test always at a minimum, thereby facilitating the work by frequently excluding for longer periods undesirable fluctuation in certain squares, also by immediately locating this fluctuation upon its appearance upon the chart coincident with the addition of a square under test, permitting the immediate exclusion of this square to avoid its interference with other tests.

The recording apparatus for this testing work should produce a chart visible at all times, have a rapid chart movement, and be quickly responsive to the smallest changes in rate of flow. The use of indicators without the chart is not satisfactory, due to the fluctuating rate of flow always occurring, even in residential sections, in the small hours of the morning. The reasons for these fluctuations constitute somewhat of a mystery, and they interfere seriously with testing where small flows are involved. The locating of the night flow first involves the use of all street valves, and when the flow is definitely determined as to quantity and location within the closest limits permissible with these valves, recourse is had to the aqua-phone or water-phone, and the operators listen with it on each curb stopcock, fire hydrant, lawn-sprinkler connection, or any other fixtures attached to the main within the predetermined limits. Examinations are also made of all sewer manholes, large sewers, electric or other ducts, and advantage is taken of every facility to determine the exact location of the flow. Flows due to fixtures or other causes within the houses or buildings are readily determined when the aqua-phones are placed against the curb stopcocks and the operators hear the flow passing through the pipe. Closure of the stopcock, causing stoppage of the sound, proves that the leak or flow is in the particular service pipe under observation or in the building supplied by it, and the amount is registered by the Pitot recorder, being the reduction in rate of flow coincident with the closure of the stopcock. Flows due to leaks on the mains or on the service pipes between the main and curb stops can be heard on the service pipes or pipe, but these flows will not be affected by closure of the stopcocks, nor will any reduction of rate of flow occur at the

recorder. The total quantity of flow due to these unaccounted for or so-called outside flows may be readily determined by a second test of the entire square with all inside flows shut off at the curb line. It is frequently necessary to drive testholes down to the mains and service pipes to permit the use of the aqua-phone

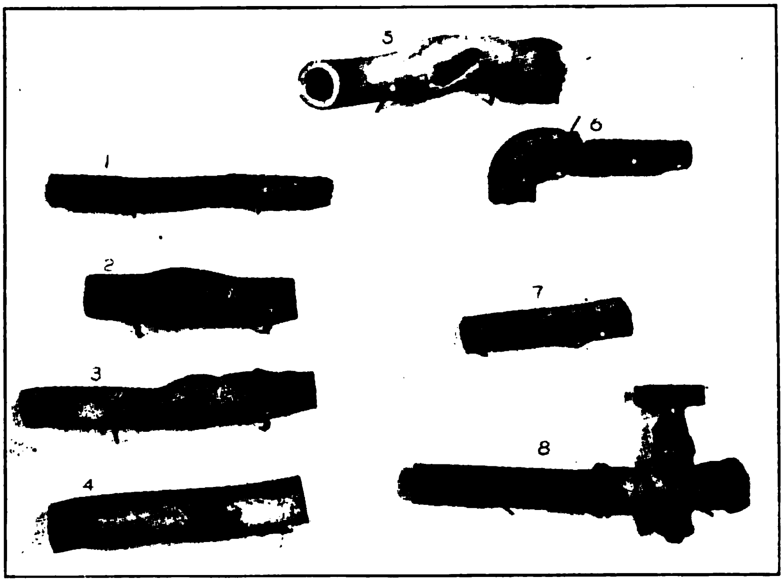

FIG. 6. SOME DEFECTIVE SERVICE PIPES FOUND BY WATER SURVEYS.

No. 1, corroded iron service; No. 2, defective wiped joint; No. 3, lead pipe damaged by bad workmanship when wiping joint; Nos. 4 and 5, frozen lead pipe; No. 6, corroded thread causing disconnection of iron service; No. 7, electrolysis of iron pipe; No. 8, broken stopcock due to abusive use of curb key.

in definitely locating an underground leak within closer limits than provided by the valves, stopcocks, or other fixtures, increasing loudness of sound at the different points indicating that the operator is nearing the leak. Frequently water or mud will be observed on the end of the steel prod used for this purpose, and this indication is utilized. Proper use of the aqua-phone is really a science, and long experience is necessary for one to become expert in its application to the underground leakage problems.

During the progress of the night tests, the operator in charge makes notes as to each step in the proceedings, and has an instru-

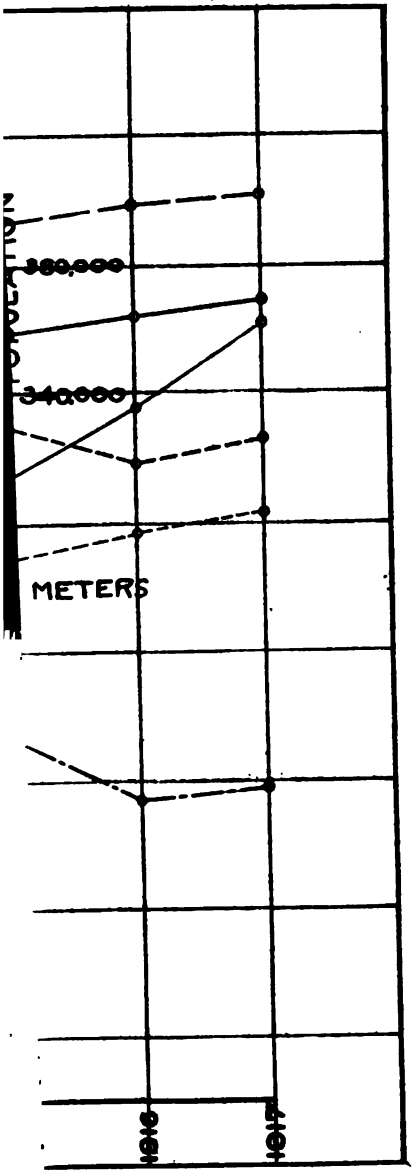

PLATE I.
N. E. W. W. ASSOCIATION.
VOL. XXXIII.
LANHAM ON
WATER-WASTE PREVENTION SURVEYS.

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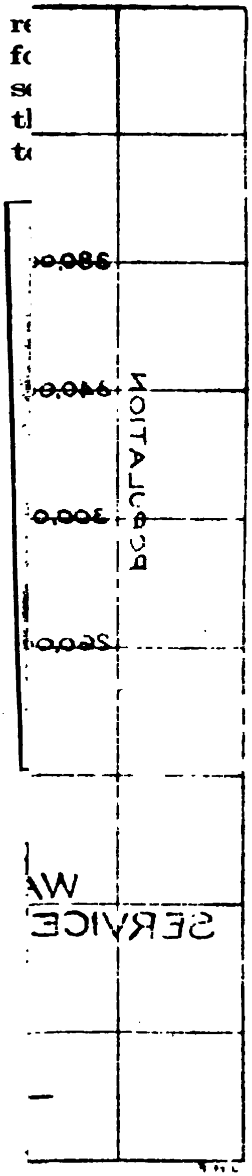
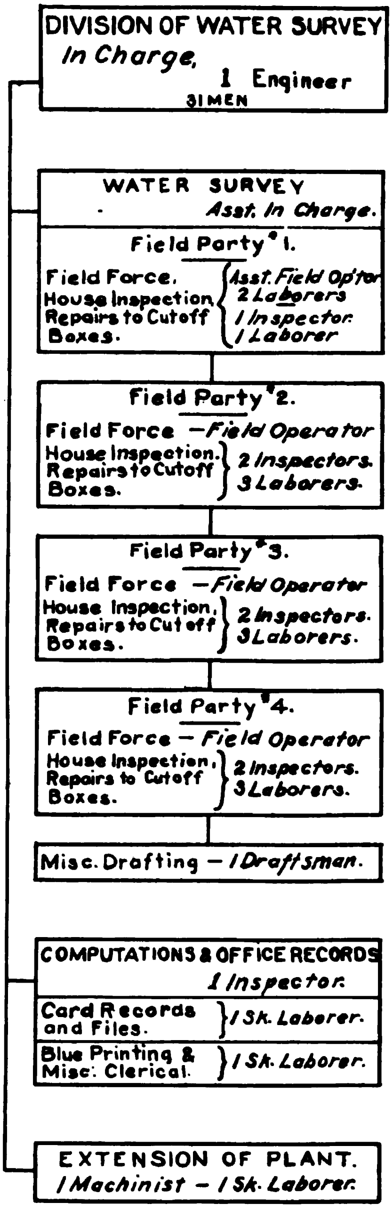


ment-tender place an identification mark upon the chart at each point corresponding with the test, signals by lanterns or otherwise being utilized, greatly facilitating interpretation of the charts; and this system is superior to the time-schedule system of testing, in which the time of test is noted to be located on the chart later. It is apparent from the description given that the basic system is very simple, and that by the exercise of care and good judgment results should be secured by any one. The difficulties met with in practice are frequently very discouraging, however, and the getting of results in spite of them taxes the ingenuity of the operators. These difficulties consist of inaccurate maps which fail to show important mains, cross connections, valves, and other features vital to the proper isolation of the districts and individual squares, inaccessible curb stopcocks which must be cleaned at the expense of much labor, broken valves and stopcocks, leaking valves, obstructed mains, unrecorded cross-connecting service pipes, and fluctuating rates of flow, causing confusion and wrong deductions.

The organization of a properly balanced force to efficiently handle the water-waste problem is a matter depending considerably upon local conditions. In general, the force should be supervised by an experienced engineer with at least one clerk and one draftsman comprising the overhead organization, and as many field parties as the circumstances demand. Each field party should consist of a chief operator and two or more inspectors, with necessary laboring force to clean out stopcock boxes, open necessary excavations, operate valves, and perform other necessary miscellaneous duties. At least one laborer is required for each inspector, and of course more will be required if many leaks are found.

Waste-prevention surveys have been made in numerous cities along the lines described, and the results have been most gratifying. In one city over 45 000 000 gal. daily underground leakage has been stopped in the past thirteen years. In another, over 2 000 000 gal. daily was the result of only one year's work by a single field party. Reference to official records of Washington, D. C.; Utica, N. Y.; Baltimore, Md.; New York City; Newark, N. J.; Havana, Cuba; Perth Amboy, Kearny, N. J., and many other places, reveals data proving the value of this work beyond all question.



ORGANIZATION CHART.

CARD ENTRIES OF DATA DETERMINED BY WATER SURVEYS OF PERMANENT DISTRICT "E," WASHINGTON, D. C.

(Note improvement of condition on second survey.)

PITOMETER DISTRICT E, SURVEY No. 1.

MEASUREMENT	9/13–19/10			
Mean daily supply				7 638 000 gal. per day
Minimum night rate				6 062 400 gal. per day
Ratio of minimum night rate to mean daily supply				79%
Per capita consumption, taken from resident population				351 gal. per day
SUBDIVISION SURVEY				
Started				
Finished				
Cost				
POPULATION		Metered	Unmetered	Total
Resident		4 281	17 460	21 741
Floating		4 069	9 575	13 644
Total		8 350	27 035	35 385
BUILDINGS				
Dwellings		427	3 826	
Hotels and apartments		51	43	
Restaurants		36	11	
Factories		21	12	
Municipal buildings		7	1	
Federal buildings		0	6	
Miscellaneous		90	422	
Total		632	4 321	
TOTAL NIGHT FLOW DETECTED BY SUBDIVISION TESTS				3 878 000 gal. per day
Due to flow inside metered premises			300 300	gal. per day
Due to flow inside unmetered premises			1 282 000	gal. per day
Due to underground leakage				
Services	1 070 200			gal. per day
Mains	173 200			gal. per day
Unclassified	300			gal. per day
Total			1 243 700	gal. per day
Due to municipal consumption			59 200	gal. per day
Due to federal consumption			411 400	gal. per day
TOTAL FLOW ACCOUNTED FOR				3 296 600 gal. per day
TOTAL FLOW UNACCOUNTED FOR				581 400 gal. per day

PITOMETER DISTRICT E, SURVEY No. 2.

MEASUREMENT 4/19–25/12			
Mean daily supply			6 149 800 gal. per day
Minimum night rate			4 156 800 gal. per day
Ratio of minimum night rate to mean daily supply			68%
Per capita consumption, taken from resident population			282 gal. per day
SUBDIVISION SURVEY			
Started		8/17/11	
Finished		4/28/12	
Cost		$3 280.26	
POPULATION	Metered	Unmetered	Total
Resident	4 783	17 079	21 862
Floating	7 689	7 625	15 314
Total	12 472	24 704	37 176
BUILDINGS			
Dwellings	361	3 659	
Hotels and apartments	50	17	
Restaurants	40	6	
Factories	14	18	
Municipal buildings	9	8	
Federal buildings	4	10	
Miscellaneous	196	558	
Total	673	4 272	

TOTAL NIGHT FLOW DETECTED BY SUBDIVISION TESTS			2 072 700 gal. per day
Due to flow inside metered premises		388 700	gal. per day
Due to flow inside unmetered premises		564 600	gal. per day
Due to underground leakage			
Services	397 500		gal. per day
Mains	59 600		gal. per day
Unclassified	800		gal. per day
Total		457 900	gal. per day
Due to municipal consumption		52 000	gal. per day
Due to federal consumption		490 500	gal. per day
TOTAL FLOW ACCOUNTED FOR			1 953 700 gal. per day
TOTAL FLOW UNACCOUNTED FOR			119 000 gal. per day

DISCUSSION.

MR. FRANK L. FULLER. Did the water takers coöperate with you in the work you were doing, and was their coöperation necessary?

Mr. Lanham. In our work on the night test, we had no way during that night test to have access to the houses.

Mr. Fuller. You could have notified them, couldn't you?

Mr. Lanham. We determined a leak inside the premises by the aqua-phone inspection at night, and the next day the inspector went back to that house to determine whether that was due to an underground leak between the curb stopcock and the house, or to some fixture within the house. If it was a leaky fixtu e, or something that could be repaired, notice was served on the owner to have it fixed. If it was simply a running faucet, careless waste, we had no remedy, as nobody could attempt to follow it out.

Mr. Fuller. I suppose you could make some estimate, couldn't you, of the amount that was running?

Mr. Lanham. We had to make an estimate of the water running from our test of the night before. Our inspector used his judgment to a large extent to determine whether that flow was sufficient to account for the flow charged against that service. In the case of a heavy flow on the night test, and the finding of an insignificant leak on the premises, it would be obvious that there was some other cause, and in that case we would proceed to eliminate the leak inside of the house to see if there was an underground leak on the pipe, which would not, of course, be heard until the other was eliminated.

Mr. Dow R. Gwinn. What percentage of the service pipes are metered in Washington?

Mr. Lanham. I think they had about 75 per cent. metered, but there have been some 10 000 meters taken out for repairs.

Mr. George H. Abbott. Have you ever had any experience with Darley's leak detector?

Mr. Lanham. We have used some of the more sensitive microphones, and the inspectors seem to prefer the aqua-phone. My personal experience has been practically all with the aqua-phone. The use of the sonoscope, and some of those other sensitive instruments, was tried after I came out of the field, and I am going more on the opinion of the inspectors than on my own experience in that matter.

Mr. Abbott. Have you ever had any experience with the geophone?

MR. LANHAM. I have heard of the geophone, and I am going to make experiments with it shortly.

MR. S. H. MACKENZIE. Have you ever used the instrument that was put on the market by Darley of Chicago?

MR. LANHAM. No, sir. I have seen that advertised.

MR. MACKENZIE. You would really have to get somewhere near the pipe to detect the leak?

MR. LANHAM. It is a listening device, isn't it?

MR. MACKENZIE. Yes, it is a listening device.

MR. LANHAM. We have not tried that.

MR. MACKENZIE. How near do you calculate you have to get the iron point to the main to use the aqua-phone?

MR. LANHAM. We actually get the iron point against the main in using the aqua-phone.

MR. W. C. HAWLEY. I have used the instrument put on the market by Darley, and we found it very satisfactory. It cannot be used in the vicinity of streets on which there is heavy traffic. There are other noises to confuse. It is a very satisfactory instrument. We use it to detect leaks under concrete, and it has very interesting results.

MR. E. G. REYNOLDS. I have had the same experience with the Darley instrument. It is very good in detecting the leak. But after you know you have the leak you must find the particular spot, and we have to make about ten cuts in the permanent pavement and get down to the main and get the sound on the main. The sound grows louder as you near the point of break, and then as you pass it the sound gets fainter. The instrument is very sensitive, and you can't use it in the wind. You have to put the covered box on it.

MR. LANHAM. Have you any data on the size in gallons per day of the leak and the size of the main?

MR. REYNOLDS. This was on an 8-in. main. I do not know the number of gallons it was running.

MR. LANHAM. The work in Washington has worked down to the question of finding leaks of 300, 400, or 500 gal. per day, which are very difficult to find, and I was wondering whether the instrument you spoke of had ever been employed in the detection of small leaks.

Mr. Reynolds. We use it more to determine the point of leakage. We are not searching for leaks with the Darley instrument.

Mr. Lanham. It has a similar use to the aqua-phone instrument. We know the leak exists and then we proceed to look within the limits where that leak is, with either the aqua-phone, or possibly we could use an instrument of the Darley type, although I have not as yet.

Mr. A. P. Folwell. Is it necessary with the Darley instrument to get the sounder down on the main, or can you locate it by traversing the surface of the street?

Mr. Reynolds. No, you do not go down. You lay it on the surface of the street. You do not dig into the street at all.

Mr. Folwell. That is very interesting to me. A great percentage of our leaks are under a hard surface, very expensive indeed to dig up. If we can do that I will send for a Darley.

Mr. D. A. Heffernan. In my paper about a year or two ago I dwelt on this Darley machine on underground service pipes. The Darley machine I used on inch and a half pipe, and using the pipe locater — of course, this was a private service, 1½-in. pipe, and the service was about 1 000 ft. long, and we used the pipe locater first and located the pipe, and then took the Darley machine and went up the line, and in about 500 ft. got the sound of the leak. I told the laborer to dig down at this point, and he dug down and there was the leak on the first dig.

Mr. Lanham. I am willing to concede that the Darley machine is all right. We have had many endorsements of it, and the Darley machine will soon be in use in Washington.

Mr. Heffernan. The size of the leak perhaps would determine whether you could hear it with the Darley machine or any machine. Has your experience indicated that the nature of the leak has as much to do with it as the size?

Mr. Lanham. I think it is a case of the velocity. If you have the pipe wide open there is no greater velocity at the end of the pipe than there is through the whole pipe; therefore you do not get any sound.

Mr. Heffernan. If the pipe was broken off where it went through the manhole you probably could not detect it.

Mr. Lanham. There would not be any appreciable difference between the sound at the end of the pipe and all along the pipe. You have to pick out your leak sounds from the other sounds on the main. It is purely a case of the relative size of the aperture, I should suppose, in regard to the size of pipe the main supplies. If the pipe is large you get a low velocity up to the leak point, and the aperture produces a high velocity.

Mr. Heffernan. Before going into a district for the first time and making a survey, do you send somebody around to test all the gates, the service cocks, so as to be sure they are shut off, or do you wait until you get on the ground?

Mr. Lanham. In the work I have done, we have started the work and tried to get the valves in condition as we went along. We have done no advance work except in the matter of stopcock detection. When we have men idle we send them far ahead on the stopcock detection. In the case of Washington, the work of valve examination is all taken care of by another division of the department. We can almost count on the valves being 100 per cent. perfect. We have an entire division of valves, and they are kept in perfect condition. But in some of the work I have done in other cities, I have run into difficulty with the valves, and we have had to stop work and go into other sections and get repairs made.

Mr. Frank L. Fuller. May I ask if you get the cöoperation of the water users?

Mr. Lanham. We do not consider that. We have simply gone ahead with our tests, and where we found leaks in the houses we gave notice to have them repaired. We have served notice that the water would be cut off in forty-eight hours if they did not make repairs.

Mr. Fuller. Don't you get a lot of kicking?

Mr. Lanham. Fortunately, we do not get the kicking. We serve the notice and send a copy of the notice to another branch of the department, and all the kicking is made to that branch.

Mr. E. G. Reynolds. I have noticed in some of your reports from Washington that a great percentage of these losses occur on the service lines. I should like to know if these are actual leaks on the service mains. What percentage of the loss in the

service line is chargeable to an actual break in the service line? In other words, in our plant we are practically 100 per cent. metered, and all the water that goes through that meter would be paid for. It might be all waste water. Now, do you make any distinction in your paper between waste and water leakage?

MR. LANHAM. All of these figures given in my report are underground leakage unless it is clearly stated otherwise.

MR. REYNOLDS. I notice that about 60 per cent. of the underground leakage was on the service lines.

MR. LANHAM. Yes. Our biggest percentage of leakage has been for years, and I think every year, in the service pipes. In Washington a great quantity of the service pipe was iron pipe, and that has corroded badly, and we have found as many as six leaks on one pipe year after year.

MR. S. H. MACKENZIE. Do you use lead flange or wiped joints?

MR. LANHAM. Wiped joints have been used on the gates in the case of practically all the Washington works, but I believe now they are using lead flanges. I think we have found a few cases of lead flanges, but it is not a fair comparison of the relative advantages of the wiped joint and the lead flange, because of the relatively small number of lead flanges now in use.

WATERSHED LEAKAGE IN RELATION TO GRAVITY WATER SUPPLIES.

ROBERT E. HORTON.

INTRODUCTION.

Probably every one has noticed the apparent difference in yield sometimes occurring in the case of small adjacent similar drainage areas. When the precipitation, soil, and cultural conditions for such areas are similar, the difference in yield is no doubt often due to watershed leakage.

Watershed leakage may be defined as the passing of waters underground from one topographic drainage basin into another. The area tributary to a stream at any point may be considered as the drainage basin at that point. Watershed leakage often occurs from the upper to the lower portions of the same drainage basin, that is to say, some of the waters naturally tributary to the stream, above a certain point, do not enter the stream above the point, but pass underground into the stream at some lower location.

Watershed leakage may also be defined as a condition where the boundary of the ground-water horizon supplying the stream is not coincident with the surficial watershed line. Nearly all large artesian systems involve watershed leakage, but this discussion will be mainly limited to its occurrence in conjunction with the surficial ground-water horizon.

Watershed leakage from the upper to the lower portion of the same drainage basin, or from the lower portion of a tributary to the stream it enters, is commonly called " underflow " in the West. Its occurrence requires that the ground-water horizon shall lie below the level of the stream bed. In such cases water may be lost from the stream directly by percolation from the stream bed, or there may be no such loss, since the bed of the stream frequently becomes watertight or impervious as a result of the silting up of the pores in the stream bed material.

A stream channel of this character has been described by

O. E. Meinzer as an " insulated stream." If there is loss from the stream channel, all the water may disappear during the dry season and the stream become intermittent in a given reach, having a visible or surface flow only during floods, such run-off as occurs at other times being in the form of underflow. This condition is a common one on rivers of the plains.

Watershed leakage on a large scale, in the case of plains streams, or underground rivers in limestone regions, is obvious, It is the occurrence of similar conditions on a small scale, where the phenomenon is not obvious, or might not even be suspected, to which attention is especially called. As will be pointed out, watershed leakage, of sufficient extent to seriously affect the accuracy of estimates of stream yield or run-off, is more likely to occur in conjunction with the basins of small streams than in conjunction with larger rivers.

Many gravity water supplies, and some high head power developments and irrigation systems, are dependent on the yield of relatively small drainage basins, which often lie at high elevations. Rainfall records in such basins and gagings of the yield of such small areas are much less common than in the case of large drainage basins, and in estimating the available yield it is frequently necessary to depend upon studies based on rainfall and water losses, gagings of other streams, or these data in conjunction with limited gagings of the stream in question.

On account of the simplicity and uniformity of conditions commonly prevailing over the area tributary to a small stream, gagings of the run-off from small areas should afford valuable data for the determination of the laws of stream flow. Conversely, it should be possible to estimate the water losses from such small areas more readily and accurately than in the case of large areas with complex and diversified soil and cultural conditions. In either case it is necessary, in order that the results may be correctly applied, that the basins under consideration should not be affected by watershed leakage.

In view of the considerations which have been presented, it appears that when any small drainage basin is proposed as a source of upland or gravity water supply, or for similar uses, where watershed leakage is liable to occur, the yield should be

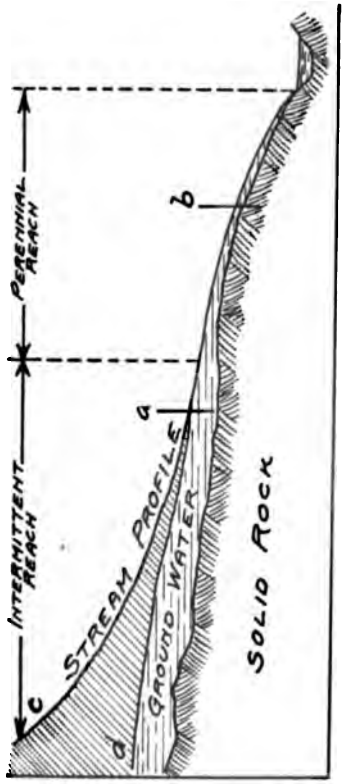


FIG. 1 - WATERSHED LEAKAGE FROM UPPER TO LOWER PORTION OF SAME BASIN

determined by gagings, if possible. In the absence of a long-gaging record, measurements during a dry period, in conjunction with observations of rainfall, are very desirable. If the occurrence of watershed leakage is suspected, the drainage basin should

be examined with reference thereto. During high water, watershed leakage on a limited scale may affect the run-off of a drainage basin but little, since the ratio of ground-water supply to surface run-off is then often relatively small. Gagings taken during low water may, however, show results per unit of topographic area considerably greater, or less, than those obtained from adjacent similar basins not subject to watershed leakage. A critical study of the underground water conditions may reveal evidence of watershed leakage sufficient to fully account for the apparently anomalous result of the gagings.

Conditions of Occurrence of Watershed Leakage.

Streams or their tributaries which have no branches may for convenience be called "first-order" streams or tributaries, — those which branch once, "second-order" streams, and so on.

Nearly all first-order streams are intermittent or evanescent in their headwater reaches. The reason for this is illustrated by Fig. 1, in which $c — a — b$ represents the stream profile, and $d — a — b$ the profile of the ground-water horizon. The depth to ground water commonly increases with the height of the land. Streams near their sources, owing to their small eroding power, have not as a rule cut their channels deep enough to intercept the ground-water horizon, and are therefore intermittent, flowing only after rains or when snow is melting.

In Fig. 1 the stream shown would be intermittent above the point a, and perennial below this point. Infiltration through the soil on the area above a provides ground water which supplies the stream below a. The surface run-off of the stream above a is less than the total yield of its tributary area, the excess passing as underflow into the area below a.

Since the fingertips of the drainage net of a stream are mostly first-order tributaries, subject to these conditions, it follows that there is usually a belt surrounding a drainage basin just within the watershed line (excepting in case of very impervious areas), from which the run-off occurs partly through the intermittent surface streams and partly through the underflow of ground water to lower levels.

If the dividing ridge between two drainage basins is impermeable, there will be no watershed leakage. Watershed leakage in general only occurs where there is a continuous ground-water

CONDITIONS FAVORING WATERSHED LEAKAGE

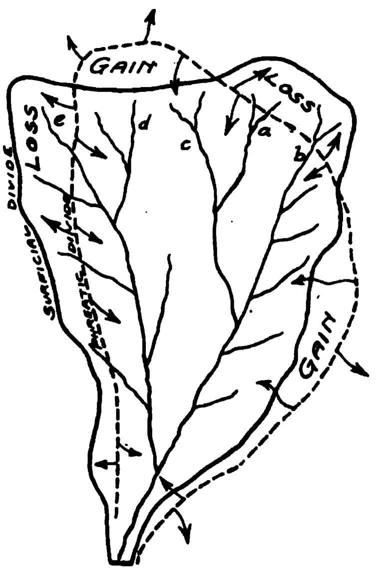


FIG. 2

ARROWS INDICATE DIRECTION OF FLOW OF GROUND WATER

horizon under both drainage basins or portions of drainage basins affected.

In general, the flatter the dividing ridge and the more sparse and infrequent the streams, the greater as a rule is the likelihood of watershed leakage. In large, flat permeable areas the topo-

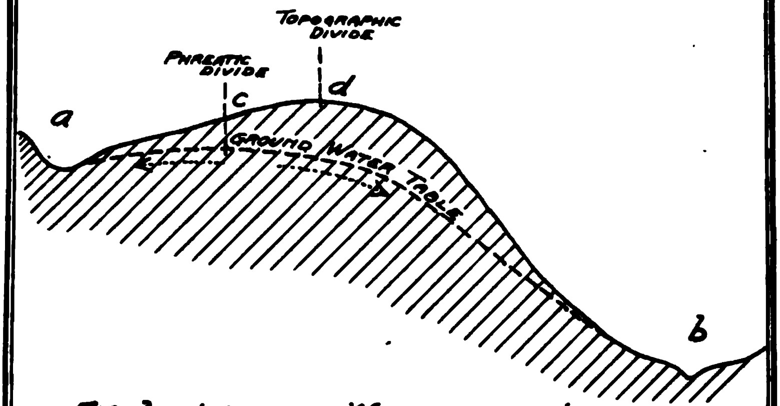


Fig. 3 – Lateral Watershed Leakage across a Permeable Divide.

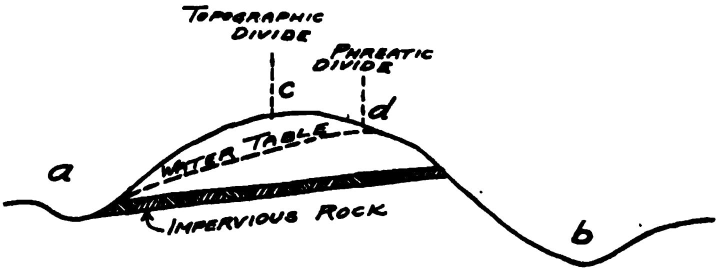


Fig. 4 – Lateral Watershed Leakage induced by Dip of Impervious Rock.

graphic and underground water divides will frequently cross and re-cross. The run-off relations for the headwater ramifications of the river system may thus be rendered very complex, there

being inversion to one and diversion from another such tributary. Taken over the whole of a large area the local effects will often be largely neutralized.

Such conditions are illustrated by Fig. 2, in which the solid line indicates the topographic, and the dotted line the phreatic or underground water divide. In this case, taking the basin as a whole, the surficial and underground drainage areas are about equal. Some of their individual tributaries have their yield increased, as *c* and *d*, while the yield of others, as *a*, *b*, and *e*, is greatly decreased, by watershed leakage.

The ratio of the area to the perimeter of a drainage basin increases in proportion to the area. Watershed leakage from a large basin usually occurs around the perimeter, so that the effect of watershed leakage on a given percentage of the periphery of a large drainage basin is less, relative to the total yield of the basin, than in the case of a small drainage basin. The likelihood of the occurrence of opposite effects, tending to neutralize one another, is always greater in the case of large than in the case of small areas. As a result of these conditions, the occurrence of watershed leakage in a sufficient degree to materially affect the accuracy of estimates of run-off is more probable in the case of small than of large drainage basins.

A condition necessary for the occurrence of watershed leakage is the existence of an outlet for ground water at a level lower than that of the stream draining the basin from which the water is derived. If the divide between two adjacent drainage basins is not impervious, and the stream on one side has cut to a lower level than the other, the lower stream may receive watershed leakage from the higher basin. Such leakage may occur either through sand and gravel, or through non-impervious rock, such as sandstone or limestone, under suitable conditions. Figs. 3 and 4 illustrate this.

In Fig. 3 the streams *a* and *b* are parallel, and the figure shows a cross section of their valleys and of the ridge between them. While the form of ground-water table is generally similar to that of the overlying soil, under the conditions shown, the ground-water divide would generally be to the left of the topographic divide, and if the soil were permeable, the stream *b* would receive

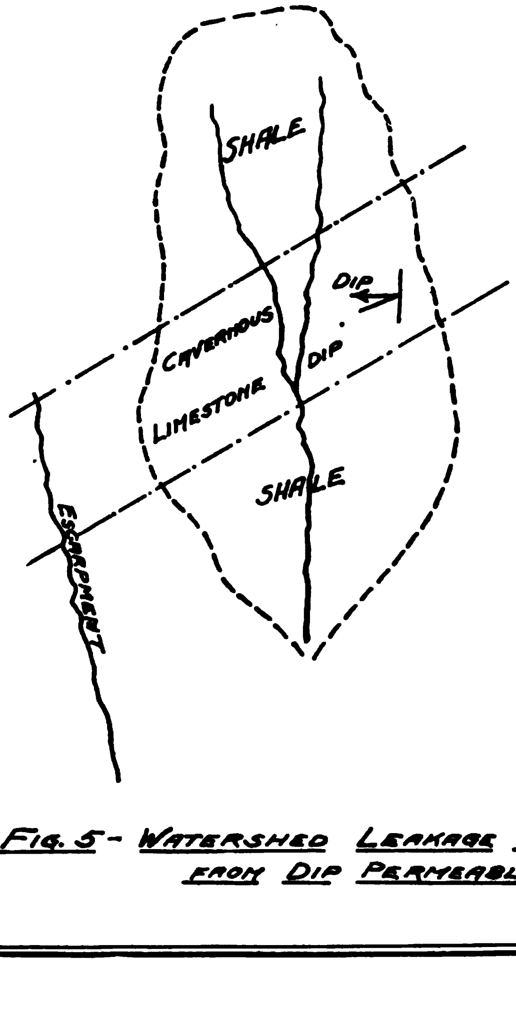


FIG. 5 - WATERSHED LEAKAGE RESULTING FROM DIP PERMEABLE STRATA.

the ground water from a strip $c - d$, the surface run-off from which is tributary to the stream a. In this case it is assumed that there are deep permeable deposits above the rock. These conditions may be reversed, as shown in Fig. 4, by the existence of impervious rock with suitable dip.

In Fig. 4, if the rock were horizontal or the deposits of permeable materials were of great depth, the conditions would be similar to those in Fig. 3. In the presence of impervious rock dipping towards the upper stream, the ground-water divide is thrown over to the right, and stream a receives the ground-water flow from a strip $c - d$ of area, the surface run-off from which is tributary to the lower stream.

Fig. 5 illustrates further the occurrence of watershed leakage due to permeable rock strata of suitable dip. Fig. 5 shows conditions existing relative to Schoharie Creek, the basin of which is crossed by cavernous limestone of the Helderberg formation. This limestone outcrops in the Helderberg escarpment at a level lower than that at which the creek crosses it. The existence of these conditions in conjunction with the notably small summer yield of the stream suggests the possibility of watershed leakage.

Fig. 6 illustrates conditions at the head of Graefenburg Creek, near Utica, N. Y. The water table underneath the hill shown lies at a depth of about ten to twenty feet. The dry run $a - b$ receives the surface run-off to the left of the line $c - d$, but this stream valley is not well developed and has not cut down to the ground water. Apparently, ground water flows in the direction indicated by the arrows, and is tributary to the perennial stream $e - f$, which originates near the foot of the steeper northerly slope of the hill.

Conditions under which small direct tributaries of large streams may lose ground water by underflow are illustrated by Fig. 7. The area directly tributary to the large stream, between the smaller streams, is the triangle $a - b - c$, but the ground water from a considerably larger area enters the main stream directly, reducing the yield of the tributaries. This condition is likely to occur around a lake margin or on a broad valley plain, filled with alluvial deposits.

An impervious rock divide will, of course, prevent watershed

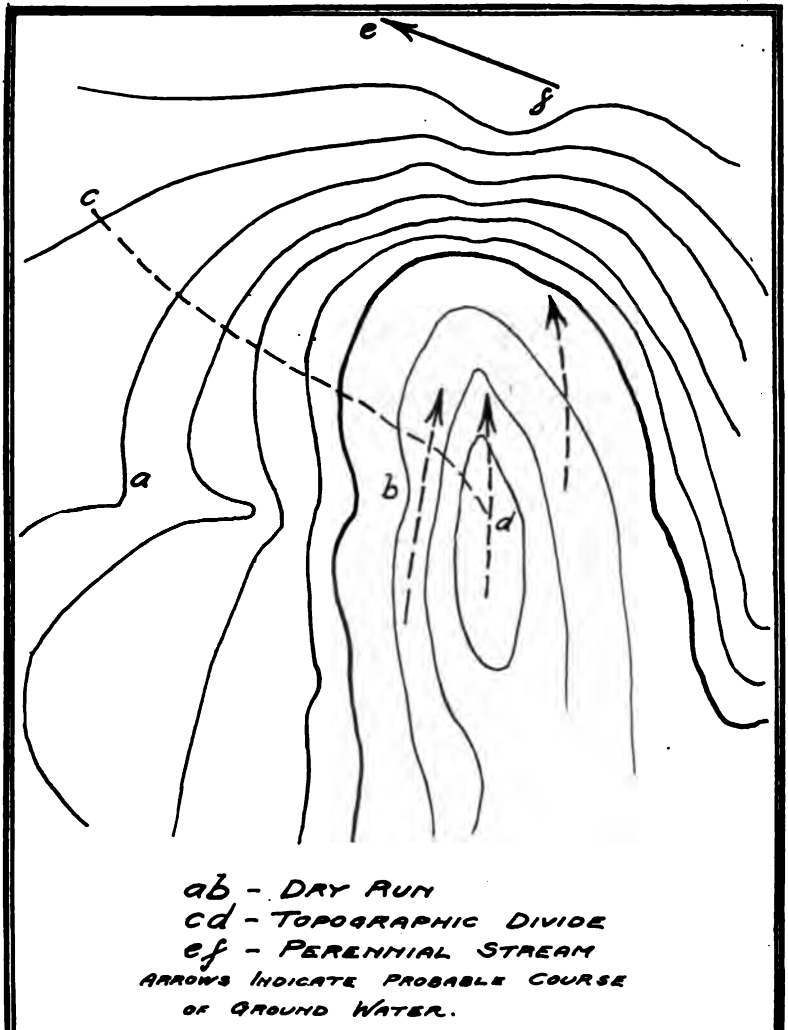


Fig. 6 - Probable Inversion of Ground Water to Head of Graefenburg Creek near Utica, N.Y.

leakage between adjacent basins, and if the soil is so shallow that there is no perennial ground water underneath the basin the effects of watershed leakage, if any, will be greatly reduced.

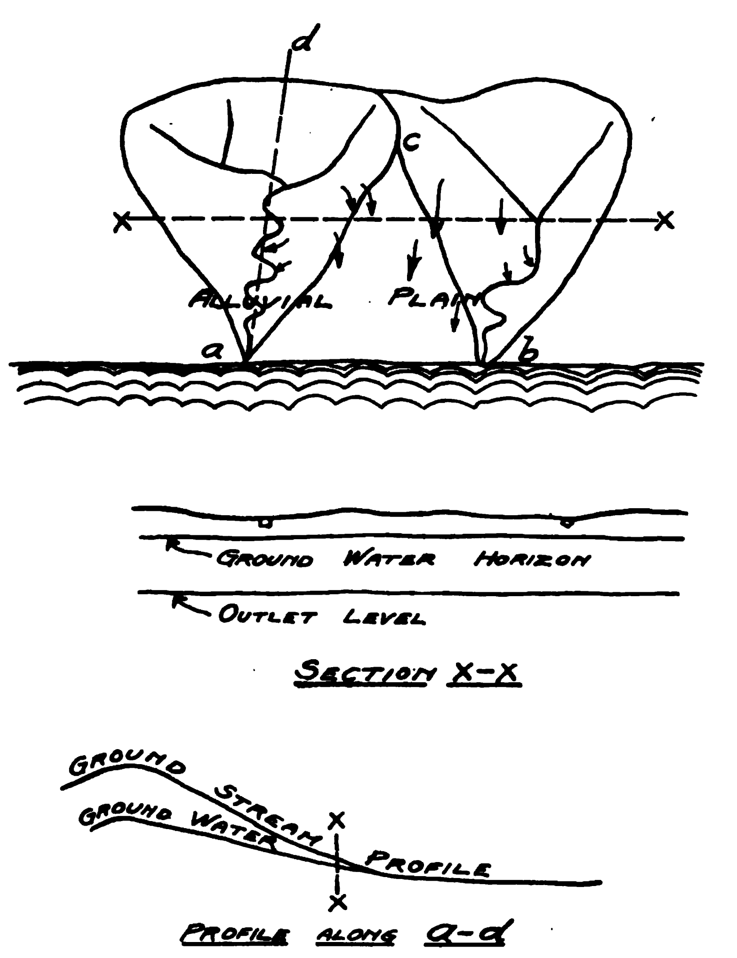


FIG. 7- CONDITIONS SUITABLE FOR WATERSHED LEAKAGE UNDER AN ALLUVIAL PLAIN.

The mere existence of rock strata in suitable position to permit of watershed leakage cannot be taken as positive evidence that such leakage occurs, since the water passages in rocks rapidly

decrease in size and number, as a rule, as the depth below the surface increases; however, in limestone regions it is possible that formations which at one time became honeycombed with solution channels have been subsequently depressed and overlain with other materials, affording opportunity for watershed leakage on a large scale. Conditions similar to these have given rise to the great springs of water in Florida, — Silver Spring, for example, which yields a constant flow of about 700 cu. ft. per second, and has but little visible tributary area.

Watershed Leakage in Regions of Deep Glacial Deposits.

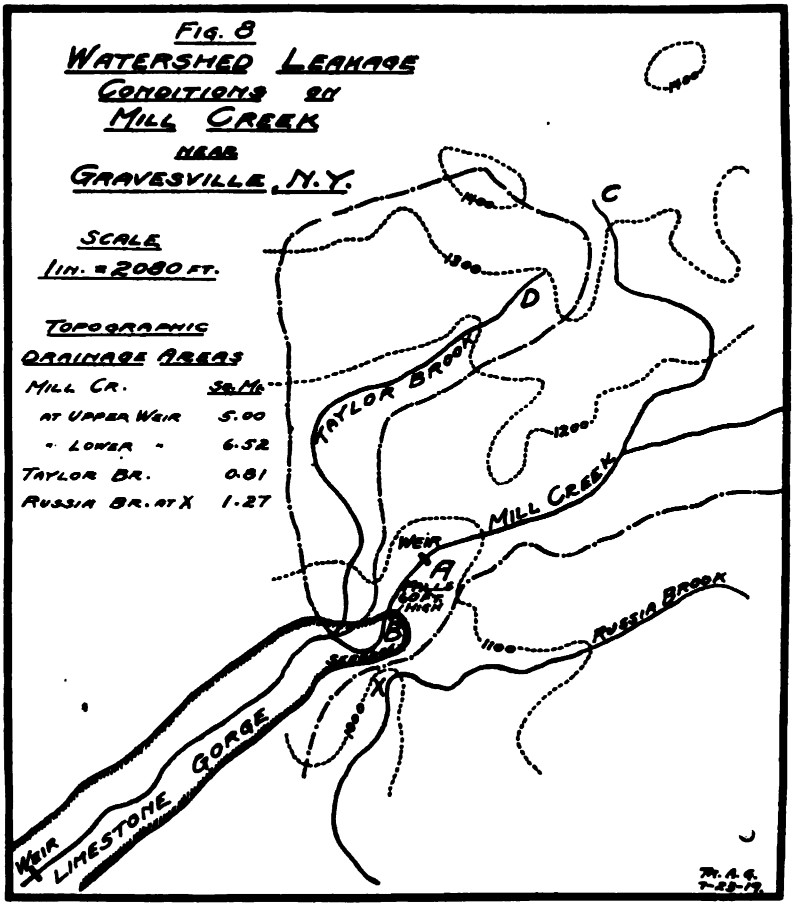
In glaciated regions the topographic drainage basin of a stream often includes numerous undrained depressions. These contribute no direct surface run-off to the stream but may contribute largely through underground flow. This constitutes sub-watershed leakage, occurring within the main drainage basin itself.

A considerable percentage of the area within the basins of the upper Kalamazoo, Grand, and Huron rivers, in the deeply filled Pleistocene deposits of southern Michigan, contributes to the streams only through watershed leakage of undrained depressions.

Small glacial lakes at somewhat different levels and separated by low divides of loose materials, often afford examples of watershed leakage.

It is common to hear the statement that a certain well, lake or stream, has no visible sources, but is spring-fed, and has an inexhaustible supply.

In a region where rainfall exceeds evaporation, no hidden or unusual source is needed to maintain a lake in a basin or depression with an impervious bottom. Precipitation on the lake surface above is sufficient. Lakes maintained in this way are usually, however, susceptible to drought, for then the supply is cut off, and the evaporation loss is usually at a maximum. In some cases lakes with no visible inflow or outflow are merely great natural wells, often of glacial origin and extending below the general ground-water horizon, — such for example as Lake Ronkonkoma on Long Island. Such natural wells may be depended upon for considerable water supplies, but such cases are



rare, and lakes or ponds having no visible sources and which must derive their supplies mainly by watershed leakage from surrounding areas, require careful investigation before adoption as sources of water supply.

Watershed Leakage near Gravesville, N. Y.

The conditions are illustrated by Fig. 8. Mill Creek and Taylor Brook drain the west slope of a group of high glacial sand hills. Both are very steady streams. Russia Brook drains a flatter sandy area to the south. Its yield in dry weather is relatively

small. The basins are all underlain by Trenton limestone, somewhat fissured, and a fall of about sixty feet occurs on Mill Creek at *B*, Fig. 8. Taylor Brook enters the gulf some distance below this fall, whereas Russia Brook comes down to within about twenty feet of the brink of the gulf, and then turns southward, not entering Mill Creek. A weir has been maintained on Mill Creek for three years, and a second weir has been maintained on the same stream below the influx of Taylor Brook and in the deep gorge below the falls. The upper weir at *A* showed a yield about equal to the normal for the same precipitation through this locality, perhaps slightly deficient. The lower weir showed a yield twenty-five per cent. greater, and somewhat above the amount that would be expected from the topographic drainage basin. Both weirs are of concrete on rock foundations with steel crests. The difference in yield at the two weirs, which are less than one mile apart, is easily accounted for from the topographic and geologic conditions.

(1) Seepage enters Mill Creek opposite the point *X*. This affords direct ocular evidence of watershed leakage from Russia Brook. This would be expected, since the surface soil is coarse sand, underlain by fissured limestone.

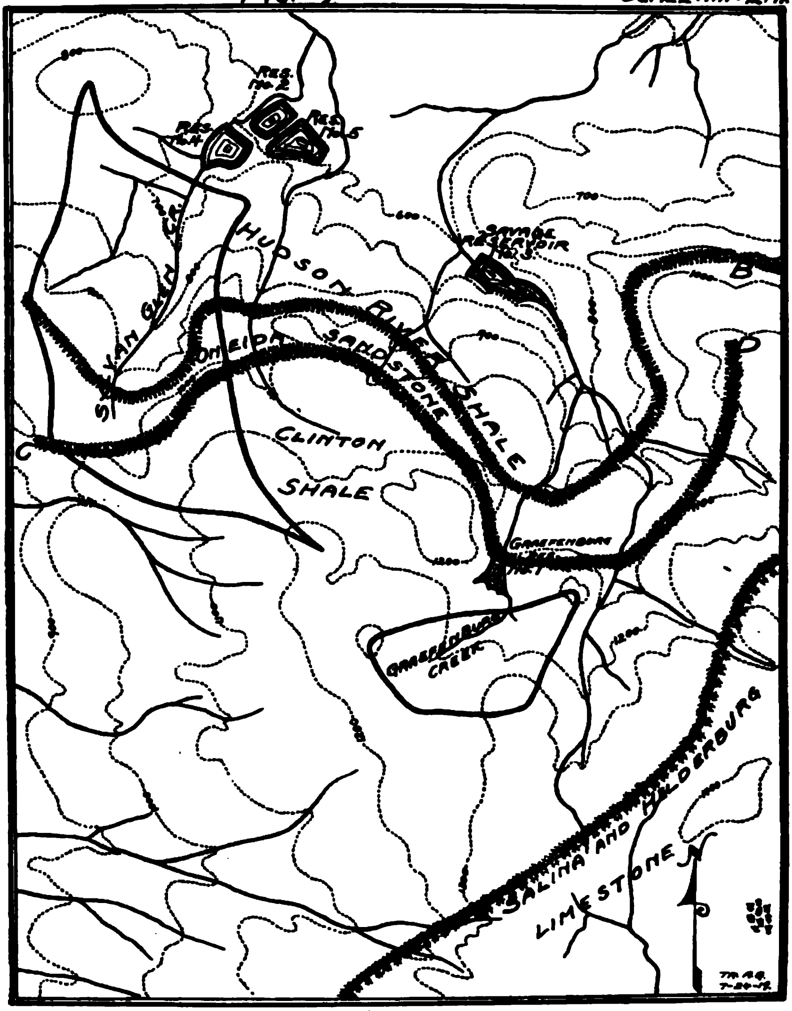
(2) It appears probable that Taylor Brook, which is a short stream, growing rapidly in volume, and an exceedingly good water yielder, receives underflow from a portion of the drainage basin of Mill Creek which is tributary on the surface to the branch of Mill Creek marked *C*. It is possible also that there is some watershed leakage into the area directly tributary to Mill Creek below *A*, since the surface drainage of this area is partly through sinkholes and sub-surface channels. The conditions here would

GAGINGS OF MILL CREEK AT GRAVESVILLE, N. Y.

Hydrologic Year.	Precipitation.	Yield, Upper Weir.	Inches, Lower Weir.
1914–15..........	46.60	22.58	....
1915–16..........	41.71	26.37	....
1916–17..........	51.62	28.65	36.69
1917–18..........	45.18	....	35.74

TOPOGRAPHIC AND GEOLOGIC CONDITIONS
IN RELATION TO WATERSHED LEAKAGE
NEAR UTICA, N.Y.
— FIG. 9 —

SCALE: 1 in = ½ Mi.



naturally be expected to produce the results found from the gagings. It will be noted from Fig. 8 that, owing to the narrow divide at *X*, diversion of Russia Brook into Mill Creek is ap-

proaching. This is hardly a true case of piracy, in the physiographic sense, since it will probably result from the cutting outward of the bend at *X* on Russia Brook rather than from aggressive action of Mill Creek; still it illustrates an apparently general principle: that stream piracy is usually preceded by subdiversion.

Sylvan Glen and Graefenburg Creeks.

The location of the drainage basins and the underlying geologic conditions for these streams are shown by Fig. 9. The drainage basin of Sylvan Glen Creek is practically all underlain by Hudson River shale, extending to a great depth, and which contains little or no ground water. The average elevation of this basin is about 700 ft. above tide.

Graefenburg Creek Basin is underlain by Clinton shale which is not quite so compact and impervious as the Hudson River shale. This basin is at an average elevation of about 1 200 ft. above tide.

Referring to the accompanying Table 1, it will be noted that the mean depth of run-off, for five years, of Graefenburg Creek is much greater than that of Sylvan Glen Creek. Taking the averages by individual months, it is found that the run-off depths of the two basins are practically equal in the flood months March and April. Sylvan Glen Creek is very nearly dry during midsummer months, whereas the average yield of Graefenburg Creek in the midsummer months is about 1.5 in. per month. Two rainfall records are given, both taken with standard Weather Bureau gages. The one at the Savage Reservoir, elevation 700, shows six inches greater precipitation than the one at Graefenburg. On the face of the records, the higher run-off corresponds to the lower precipitation. These apparently anomalous results are readily explained, for the most part, by the fact that examination of the drainage basin shows an outcrop of Salina and Helderberg limestone adjacent to the Graefenburg area, from which large springs issue and enter Graefenburg Creek.

In the case of Sylvan Glen Creek, the stream is commonly dry during the summer months, a little distance above the weir, where it flows over solid rock. The weir is, however, located on a delta plain below the mouth of the rock gorge and there is evi-

TABLE 1.

COMPARISON OF MEASURED YIELD OF SYLVAN GLEN AND GRAEFENBURG CREEKS NEAR UTICA, N. Y.

Annual Yield.

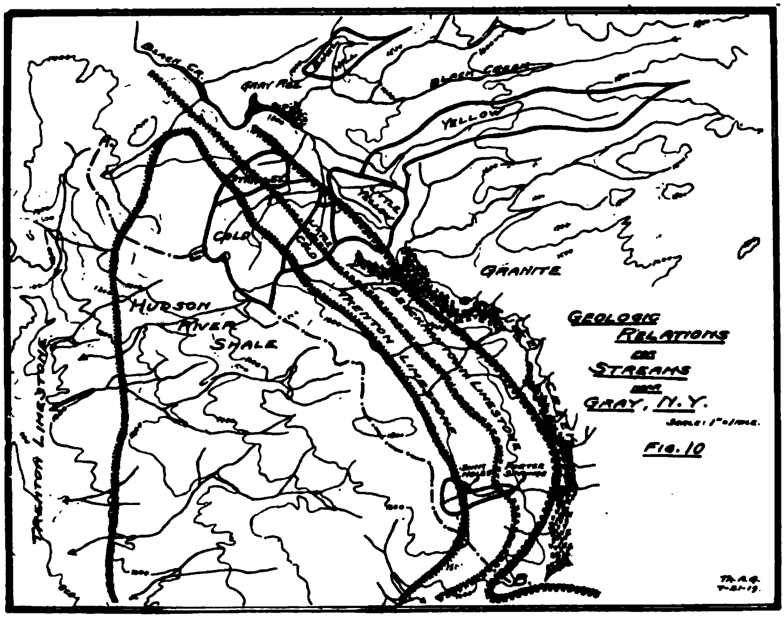
Year.	Precipitation.			Annual Yield, Inches, Depth.	
	Savage Res.	Graefenburg Res.	Deerfield Res.	Graefenburg.*	Sylvan Glen.†
(1)	(2)	(3)	(4)	(5)	(6)
1908......	36.28	31.49	33.19	30.06	13.54
1909......	43.12	37.52	36.07	27.65	21.77
1910......	43.64	35.94	40.70	27.70	17.35
1911......	44.18	36.99	40.23	26.46	17.98
1912......	46.25	39.79	35.65	32.51	24.50
Average...	42.69	36.35	37.16	28.87	19.03

Monthly Average Yield, Five Years, 1908–1912.

Month.	(2)	(3)	(4)	(5)	(6)
Jan........	2.64	2.11	2.23	2.33	1.82
Feb........	3.43	3.12	2.87	2.66	2.07
Mar........	2.62	2.44	2.18	4.73	4.60
Apr........	3.15	2.84	2.84	4.27	4.61
May......	4.77	4.38	4.41	2.70	1.68
June......	4.04	3.04	3.68	1.83	0.56
July.......	4.11	2.73	3.19	1.48	.064
Aug.......	3.88	3.35	3.22	1.45	.078
Sept.......	5.93	4.93	4.48	1.78	.494
Oct........	3.54	2.90	2.90	1.66	.466
Nov.......	3.26	2.61	2.73	1.97	1.13
Dec.......	2.52	1.91	2.45	2.04	1.46
Year......	42.69	36.35	37.17	28.9	19.03

* 0.35 sq. mile, formerly taken as .281 sq. mile.
† 1.18 sq. mile.

dence of some loss of water by underflow. These conditions account for the differences in yield, regardless of rainfall. As to the rainfall, the Savage or lower gage is on a steep northerly slope, well protected from south and west winds but possibly receives more than its true precipitation, owing to eddying effect of the wind blowing over the crest of the slope. The Graefenburg



Reservoir gage is on a high plateau, freely exposed to the sweep of the wind, and undoubtedly records less than the true precipitation.

These conditions and records illustrate the difficulty of estimating the yield of small drainage areas from limited data, and emphasize the necessity of taking into account all the surrounding conditions.

Conditions of Streams Tributary to Gray Reservoir.

Weir measurements have been kept for ten years on each of five small streams tributary to Gray Reservoir in Herkimer County, N. Y. The location of the drainage basins relative to

TABLE 2.

CHARACTERISTICS AND YIELD OF STREAMS TRIBUTARY TO GRAY RESERVOIR, HERKIMER, N. Y., NOVEMBER, 1908, TO OCTOBER, 1918, INCLUSIVE — TEN YEARS.

Stream.	Area Sq. Mi.*	Culture — Per Cent.				Underlying Rock.	Elv. Head of Basin.	Elv. at Weir.	Mean Slope, Ft. per Mile.	Precipitation, Inches.	Measured Yield, Inches.			Apparent Water Losses.
		Open Swamp.	Wooded Swamp.	Highland Woods.	Meadow.						Nov. — April.	May — Oct.	Year.	
(1)	(2)	(3)				(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Yellow Brook...	2.12	0	5	90	5	Granite	1 500	1 330	350	48.61	22.44	12.69	35.13	13.48
Little Yellow...	0.766	0	70	25	5	Gr. 75% Ls. 25%	1 860	1 330	300	48.61	23.70	11.59	35.29	13.33
Stanley........	0.469	0	10	5	85	Sh. 5% Ls. 85%	1 510	1 330	250	48.61	19.90	12.48	32.38	16.23
Cold...........	1.353	5	20	10	65	Sh. 60% Ls. 40%	1 550	1 340	250	48.61	20.48	11.21	31.69	16.92
Little Cold.....	0.798	10	20	30	40	Sh. 15% Ls. 85%	1 700	1 380	250	48.61	21.56	11.35	32.91	15.71
Bull Hill.......	0.332	5	15	10	70	Granite	1 600	1 330	330	48.61	....	....	31.65†	....

* From transit survey of watershed. † 1908–13.

the underlying geologic formations are shown in Fig. 10, and the areas of the drainage basins and the characteristics in measured yield in the different streams are shown by the accompanying Tables 2 and 3.

The weirs are of similar construction, of concrete, with steel crests, and all readings were taken by the same observer. The tributary areas were determined by transit survey of the watershed lines. It will be noted that the two streams draining granite areas show about three inches greater yield per year than the streams draining areas underlain by limestone and shale. The streams on granite areas contain larger percentages of woods than the others.

At first sight, the larger annual yield of the wooded granite areas might be attributed to the conservation of water by the forests. This, I think, is not the case. The grass areas quite certainly consume less water in vegetative processes than do the

TABLE 3.

RELATIVE YIELD OF GRAY, N. Y., STREAMS ON GRANITE AND LIMESTONE FORMATIONS, 1908–1918 INCLUSIVE.

	Granite Areas, Yellow and L. Yellow.	Limestone Areas, Cold, L. Cold, and Stanley.
	Inches.	Inches.
January	2.50	2.36
February	2.74	2.36
March	3.74	3.39
April	7.28	5.57
May	3.18	2.63
June	1.62	1.64
July	1.14	1.24
August	0.83	1.10
September	1.40	1.36
October	2.23	2.05
November	2.60	2.27
December	2.04	2.00
Year	31.32	27.97
Means	2.61	2.33

forests. Furthermore, the difference in yield occurs mainly in the winter time, the apparent water losses in the granite and limestone areas being very nearly equal in the summer season, such differences as do exist being readily attributable to cultural conditions.

Spruce Creek adjoins the streams underlain by limestone on the south and at a level considerably below their basins. The outcrop of the limestone belt is at nearly uniform level. There are numerous sinkholes in this limestone, the location of some of which are shown on the map, Fig. 10.

It seems most probable that Stanley, Cold and Little Cold brooks lose some water in the underlying limestone, very likely part of this loss going northward into Black Creek, and part going southward into Spruce Creek, drainage basin. Apparently the excess of the water consumption in the summer season on the wooded granite over that of the more open areas underlain by limestone is just about sufficient to balance the watershed leakage from the latter areas.

Evidence of Watershed Leakage in the Watuppa Pond Area, Fall River, Mass.

Gagings of nine small streams, tributaries of North Watuppa Pond, Fall River, Mass., by Arthur T. Safford, C.E. (Report of the Reservoir Commission to the City Council of Fall River, 1902), covering the three complete years 1899 to 1901, show wide variations in run-off and water losses.

The locations of the drainage basins and rain gages are shown in Fig. 11. The subjoined Table 4 gives the physiographic characteristics of the different drainage basins. The outflow from North Watuppa Pond was also measured at the narrows. The evaporation was measured by a tank 5 ft. 11 in. in diameter and 3 ft. high, at the narrows gaging station. The tank was 2.25 ft. above water surface for the full pond. Water in the tank was 6.9 in. below the rim. This would indicate a large reduction due to rim factor, and it is probable that the measured evaporation from the tank was about equal to the actual evaporation from the water surface, since the effect of the rim factor would approximately compensate for the difference between surface temperature in

TABLE 4.

CHARACTERISTICS AND YIELD OF TRIBUTARIES OF NORTH WATUPPA POND, FALL RIVER, MASS., 1899 TO 1911. (ARTHUR F. SAFFORD.)*

Stream.	Area. Sq. Mile, at Weir.	Woods. Per Cent.	Culture. Per Cent.	Swamp. Per Cent.	Mean Precip. 3 Yrs. Inches.	Meas'd Yield, 3 Yrs. Inches.	Apparent Water Loss. Inches.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cress Brook	0.466	....	90 Meadow	0	44.43	10.97	33.46
Highland Brook	1.082	20–30	50	20–30	44.43	27.47	16.96
Terry Brook	0.218	20–30	50–60	10–15	44.43	29.47	14.96
Queen Gutter Brook	0.629	80 ±	Little	10–15	44.43	17.07	27.36
Run Brook	0.195	80 (Cut over)	Little	2	44.43	14.43	30.00
King Philip and Blossom	2.144	33	Little	66⅔	44.43	23.65	20.78
Ralph Brook	0.337	75	15	10	44.43	14.82	29.61
North Nat Brook	0.211	40 (Heavy)	60 Meadow	0	44.43	10.79	33.64
South Nat Brook	0.164	....	75 Meadow	0	44.43	20.32	24.11
Mean of all	5.446	....	....	.....	44.43	.....	.....

* Report of the Reservoir Commission, 1902, Fall River City Council.

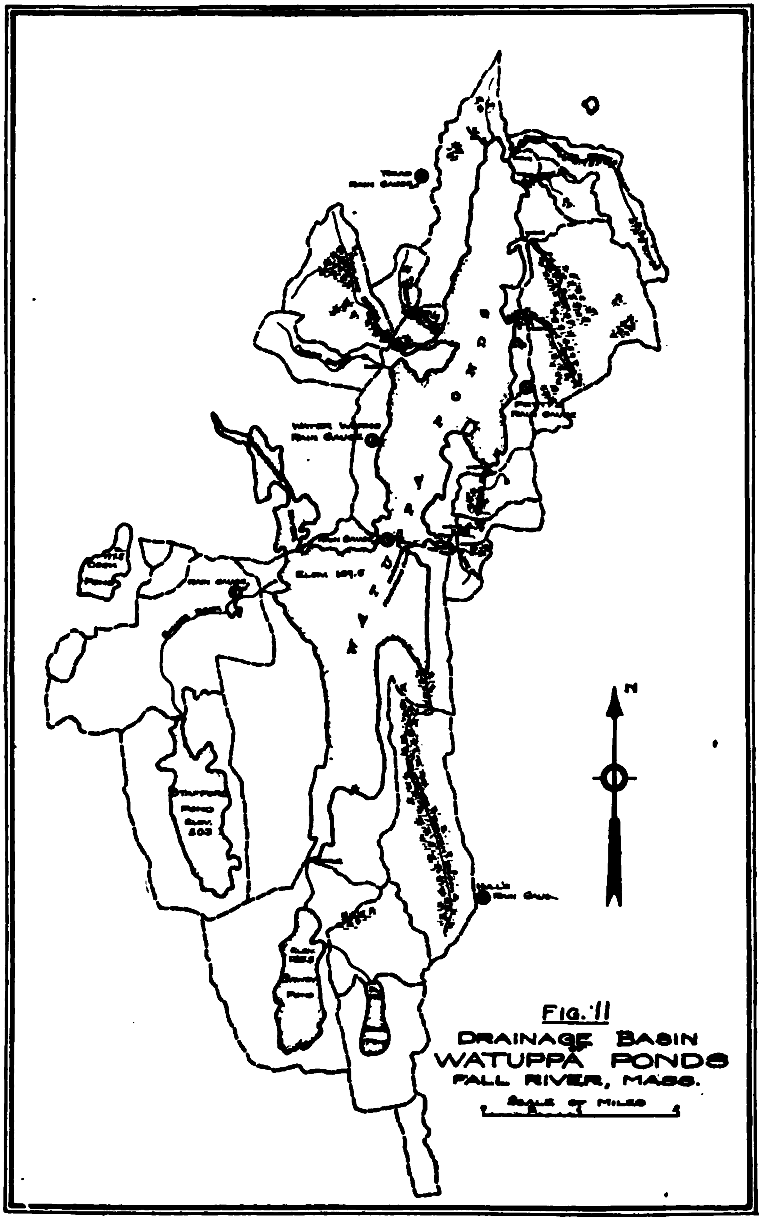


FIG. 11
DRAINAGE BASIN
WATUPPA PONDS
FALL RIVER, MASS.
SCALE OF MILES

the tank and pond and for the vapor blanket effect on the broad lake surface.

The weirs were of standard construction, and the tributary areas were determined by survey. Correcting the measured outflow from the pond for the difference between precipitation and evaporation on the water surface, Safford found that the average yield of the total area above the narrows for the three years was 18.1 per cent. greater than the average yield for the same years as indicated by the gagings of the upland areas.

The presence of open spots in the ice on the pond in winter indicates springs entering the pond. There are also some springs and seepage areas on the tributary stream basins. Mr. Safford concludes that there is certainly no inversion to the drainage basin as a whole, and that the entire outflow from the north pond results from precipitation on the tributary area. The table of results shows generally the largest run-off and smallest apparent water losses for the low-lying drainage basins which are flat, wooded and swampy. This relation holds generally for the three individual groups of streams. Only two streams show measured run-off greater than the corrected average inflow from the land area as determined from gagings at the narrows. There is evidence of watershed leakage from ,the higher to the lower-lying streams in the different groups, but apparently the major portion of watershed leakage takes place from the individual areas directly to the pond.

Streams Adjacent to Pike's Peak.

Water Supply Paper No. 437, United States Geological Survey, contains results of gagings of streams on the east slope of Pike's Peak and adjoining mountains in Colorado, for the period October, 1909, to September, 1916, inclusive.

In most instances, the differences in yield of these small adjacent drainage basins are no greater than would be expected from the differences in elevation and cultural conditions. Lyon, Sheep, and Cabin creeks drain narrow parallel basins, heading on Pike's Peak, and are all tributary to South Ruxton Brook. There is a crater toward the head of Sheep Creek basin which it is stated is

probably tributary to Lyon Creek, and the surface area above this crater has been excluded from Sheep Creek basin and included in Lyon Creek basin. The figures in Table 5 show, however, that on this basis the apparent water losses for Lyon Creek are four inches, or fifty per cent. greater than for Sheep Creek, so that the correction does not appear to be justified, and a detailed geologic study would be necessary to harmonize the results, although in view of the close identity of form, elevation, culture and exposure of these two basins, it appears that the areas actually tributary to them must be very nearly proportional in their yield.

Detection of Watershed Leakage.

The writer has felt that the practical utility of geology as an aid to engineering could be materially increased, especially along hydraulic lines.

The detection of watershed leakage affords an opportunity for the use of geologic knowledge in the interpretation of stream-flow records. Cases where watershed leakage is suspected are very numerous. There are not many instances, however, where sufficient data for full determination of the question are available. Such determination requires in general actual gagings of the stream in question; furthermore, gagings of other streams are needed for comparison, so that the relation of the measured run-off or water losses to the normals for a similar drainage basin, free from watershed leakage, can be determined. In general, water losses are less variable than either precipitation or run-off, and conclusions based on comparisons of water losses are therefore more reliable.

A map of normal water losses for a region would be a valuable aid in such studies, and could be used in a manner similar to the use of maps of normal chlorinal content, in the study of water analyses. The writer has such normal water-loss maps for the eastern United States in preparation. If a study of the run-off and water losses of a given drainage basin indicates that these are abnormal, and suggests the probability of watershed leakage, a geologic study of the drainage basin may be made. It is difficult to lay down satisfactory general rules for such a study. Obviously

TABLE 5.

HYDROLOGIC DATA, STREAMS NEAR COLORADO SPRINGS, 1909–16 INCLUSIVE.

Stream.	Square Miles.	Per Cent. of Area Below Timber Line.	Slope of Axis.	Azimuth* of Axis.	Mean Elv. of Basin.	Summer.			Winter.			Year.		
						P.	Y.	L.	P.	Y.	L.	P.	Y.	L.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Boehmer Creek.	7.20	25 Sparse	.068	S45°W	11 750	17.06	8.47	8.59	8.46	2.28	6.18	25.52	10.75	14.77
Little Beaver Creek........	1.00	75 Sparse	.180	N80°E*	11 750*	17.06	7.95	9.11	8.46	.86	7.60	25.52	8.81	16.71
Sachett Creek ..	0.65	70 Sparse	.130	S7°E	11 650	17.06	9.05	8.01	8.46	.73	7.73	25.52	9.78	15.74
Lyon Creek....	2.00	70 Sparse	.262	N80°E	11 450	17.06	5.05	12.01	8.46	2.86	5.60	25.52	7.91	17.61
Sheep Creek....	0.73	100 Sparse	.190	N80°E	10 400	17.06	8.99	8.07	8.46	3.00	5.46	25.52	11.99	13.53
S. Ruxton Creek	3.95	100 Heavy	.170	N44°E	10 600	17.06	5.91	11.15	8.46	2.07	6.39	25.52	7.98	17.54
Cabin Creek....	2.40	85 Sparse	.246	N80°E	11 400	17.06	7.27	9.79	8.46	1.90	6.56	25.52	9.17	16.35
Average........	...	....	...	......	......	17.06	7.53	9.53	8.46	1.96	6.50	25.52	9.48	16.04
Lyon-Sheep-Cabin†.......	5.13	80 Sparse	...	......	......	17.06	6.66	10.40	8.46	2.79	5.67	25.52	9.45	15.07

* Approximate. † Weighted average.

the character, uniformity, and depth of the soil overlying the basins, as well as the dip of the underlying rock, are important.

Since the existence of a stream channel perched above the surficial ground-water horizon nearly always accompanies watershed leakage, in the form of subdiversion, a study of the depth of the ground water in wells in regions in which the loss of water is believed likely to occur may be helpful.

In investigating the likelihood of watershed leakage, especially in small drainage basins such as are used for gravity water supplies, the following suggestions may be useful:

(1) Watershed leakage is always from a higher to a lower drainage basin. In case of inversion, higher-lying adjoining areas should be examined. In case of diversion, the presence of lower-lying adjoining areas which may afford an outlet for the water losses should be looked for.

(2) Aside from loss through solution channels in limestone regions, watershed leakage usually occurs only where there is a continuous ground-water horizon. It does not occur where there is an impervious rock barrier forming the boundary between the two areas in question.

(3) Watershed leakage is more likely to occur between areas overlain by deep beds of sand, gravel or porous glacial deposits than between areas with less permeable soils or with rock near the surface. It is more likely to occur in regions underlain by limestone and sandstone than in regions underlain by shale or granite. It is more likely to occur through rocks of moderate dip than through horizontal strata, — and it is more likely to occur through broken, seamy and fissured rocks than through compact, uniform beds of rock.

(4) It is more likely to occur between basins with low, poorly marked watershed divides than between steeper areas. The configuration of the surficial ground-water table generally follows closely that of the overlying topography, and the topographic forms, as well as the geologic conditions, should be taken into account.

Summarizing. — The shallower the soil mantle, and the closer to the surface the rock, the steeper the slopes, and the more impervious the soil and rock, the less is the likelihood of serious watershed leakage.

Discussion.

Mr. W. A. MacKenzie. Mr. Horton's paper has been a mighty interesting one to me, and, besides, he has brought out some very valuable data on a subject which I think has been neglected somewhat, perhaps, and it shows conclusively that the run-off from one watershed is not a criterion to go by in considering the run-off from another watershed, although its topography may be about the same.

This has been brought out somewhat in a matter which we have under consideration, where two weirs were beside a watershed of about one square mile in area, and during the six months' dry-flow the run-off from the upper area was about 30 per cent., I believe, less than the run-off from the lower, showing conclusively that in making a study for water-works development this should be more fully considered in locating the pond area, or the dam, and that if this were more fully considered perhaps better results would be obtained, and sometimes we would consider more fully the location of the dam, not overlooking perhaps in some cases the fact that a larger expenditure for a dam in a different location would bring about much better results and a larger yield for that area.

I know, in talking over the possible damages in this particular area with another engineer on the other side, we suggested this, and he said that this theory had been exploded long ago. He maintained that we were not getting the full benefit of this upper section, where we might build the dam. But our weir measurement for two years or more conclusively showed that we could not obtain the full advantage. I should like to ask Mr. Horton if this has ever been brought out in court cases on the payment of damages on the diversion of watersheds, and whether they have been able to prove, and it has been accepted and the award perhaps based somewhat on the watershed leakage.

Mr. Horton. I do not know of this question having come up, — of watershed leakage in any diversion damage cases.

Mr. L. M. Hastings. I have been interested very much in the paper. I think it is a very important subject, especially if we are considering the yield of the drainage area.

I could not help thinking of our own experiments in Cambridge, where about twenty years ago we had a development of a large watershed, about 23 square miles, and on that watershed had a secondary dam which controlled the water over about 7 square miles. This water flowed into the larger area, which was located on the upper reaches of the streams. Precisely the condition which Mr. Horton so well described took place there while we had the matter under consideration.

In the summer of 1896 or 1897, while we were building that dam, the flow from that stream practically dried up, whereas the flow on the entire 23 square miles of area maintained a fairly good yield of water, showing that for the dry weather flow, at any rate, the smaller stream in proportion to the entire watershed gave a very much smaller yield than the entire shed. I think the most casual examination of the yields of watersheds will show that fact, — that the smaller the watershed the less the yield will be and the greater the fluctuation. That is, the summer flows seem to be smaller in relation to their size in the small streams than in the larger ones. While the Merrimack River will give a steady flow, relatively speaking, through the entire season, a small, secondary portion of the yield of that watershed will give a very small yield.

In the case of the Cambridge supply in the city of Waltham and town of Lincoln, in Massachusetts, the total yield for the year on the smaller streams was very much less than the ratio of the whole 23 square miles. So that I think in trying to obtain a water supply for any community the larger the stream the more uniform and larger in extent will the flow be.

This is a well-known fact in water-power development, — the larger stream is more uniform in flow and more power is obtained. Of course if the drainage areas are small compared to the storage basin that difference diminishes, because in a degree you can carry over your storage from the heavy flow of the winter and spring. But ordinarily I think it has been found that the smaller the drainage area the smaller the practical results are that you can obtain from it.

Mr. Lincoln Van Gilder. I should like to ask Mr. Horton a question. This is in reference to our own development. We have a watershed at my city of about 18 square miles, all sand,

and covered almost entirely with scrub timber of oak and pine. The lower part, which forms the impounding reservoir, is about 250 acres in area. The bottom is formed of fine sand, but that is overlaid with silt. Now, the question comes to us, — Is it safe for us to take the silt off, or shall we leave the silt there to prevent underground leakage?

MR. HORTON: I should think that would depend somewhat on the history of the situation. If you knew whether you got a smaller yield from that reservoir in the days after it was first built and before that silt deposit had occurred, then that would afford a good basis for answering the question. My own experience has been that you are very likely to lose water by taking the silt insulation off from a stream bed or reservoir bottom if there is an opportunity to lose it. Of course, if there is no opportunity to lose it anyway, then you will not lose it. But I have known of several instances where the removal of the silt from the stream bed or reservoir bottom has had just that effect, — to permit the water to drain off for a time, until a new insulation was formed.

MR. W. A. MACKENZIE. In the case of a reservoir for a large private establishment some three years ago, they built a dam, and the owner was very anxious to have the basin of this reservoir cleaned out so that it would present a much nicer appearance for swimming pools, and so forth. So that we used a large amount of the basin material, which was a sort of clay and silt, at the bottom side of an earth dam. This dam had a concrete wall and proved to be very tight. There was a gully that was very near equal to the depth of our own pond, some 100 ft. to one side, where another stream flowed. We cleaned out this reservoir, and went up on the side of the banks considerably with the loam, clay, and silt. The water in the gully has more than doubled since the pond was filled, and up to the present time the bank has not silted up. I told the owner at the time that I thought perhaps this bank would silt up and the leakage would decrease, but up to the present time it has not. In this particular case it was not a water supply, and the leakage has not caused any damage. But it was of considerable concern to the owner, as in the dry weather there was not as much water running over the dam as there would have been otherwise. So I think that, perhaps, it is rather a risky proposition to

clean the entire basin if it is a water supply, and the material that is in the basin will not materially affect the character of the water.

Mr. Charles W. Sherman. The experience of the last speaker brings to my mind rather an interesting experience I had a number of years ago, and reminds me of what I sometimes like to call the "cussedness of inanimate things." We all know that, if we build a filter out of sand, the first thing it does is to plug up. I had to build, a number of years ago, a little dam to form a pond to add to the architectural landscape appearance of a large estate, and the only substance available with which to build it was sand. We put in concrete to such a depth as was practical within reasonable limits of expense, and I assumed that the sand embankment, with the aid of that concrete, was near enough like a filter so that it could be counted on to plug up in a few years. But to the best of my knowledge and belief it has not plugged up very much yet.

DANGEROUS REDUCTION OF INSULATION RESISTANCE IN HIGH-PRESSURE FIRE-SERVICE MOTORS, DUE TO MOISTURE.

BY WM. W. BRUSH, DEPUTY CHIEF ENGINEER, BUREAU OF WATER SUPPLY, DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY, CITY OF NEW YORK.

[*Read by* C. W. SHERMAN.]

An investigation of the change in insulation resistance of the electric motors which drive the high-pressure fire-service pumps at the four stations in Manhattan and Brooklyn has shown some interesting and rather surprising results. The story will be briefly told of what has been observed, and of what has been planned to prevent in the future dangerous lowering of the insulation resistance, in the hope that the experience of others will be set forth, and that those who have a similar operating and maintenance problem will be helped in the solution thereof.

High-Pressure Fire-Service Motors. The more important commercial sections of New York City lying in the boroughs of Manhattan and Brooklyn are afforded exceptionally effective fire protection by the high-pressure water-supply system which is used only for the extinguishment of fires. In each borough there are two stations which have pumping equipment of similar design. In each Manhattan station there are six 6-stage centrifugal pumps having a capacity of 3 000 gal. per minute when delivering against a pressure of 300 lb. per square inch, while in Brooklyn the main station has five such pumps and the reserve station three pumps. The pumps are driven by 6 600 and 6 300 volt induction motors in Manhattan and Brooklyn, respectively, those in Manhattan having been built by the Allis-Chalmers Company, and the Brooklyn motors by the General Electric Company. Ten of the Manhattan motors were installed in 1908 and two in 1911. All of the Brooklyn motors were installed in 1907. One of the Manhattan stations is on South Street, facing

the East River, while the other is on Gansevoort Street, adjoining the North River docks. The main Brooklyn station is on Joralemon Street, near the East River, and the reserve station on St. Edwards Street, about one mile from the river front. The proximity of three of the stations to the water increases the humidity of the air in their vicinity. The Manhattan and the reserve Brooklyn stations have the operating floor at the street level, while the main Brooklyn station floor is about ten feet below the street level. In all the stations the provisions for ventilation are normal. In the main Brooklyn station the basement is damp, and there is usually more moisture in evidence here than at the other stations.

Normal Operating and Maintenance of Motors. In Manhattan a motor is started upon receipt of an alarm in the district covered by the station, and the necessary pressure maintained until notice is given by the fire department that no further supply is required. The number of times the service is required averages 550 per year for each station. In addition, every twenty-four hours each motor is started and run for about five minutes, when not otherwise put in service. This operation is mainly for the purpose of testing the condition of the motors and pumps, but also helps to dry out the motors. In Brooklyn, up to the introduction of the Catskill water, the proper station covering the district affected started a motor on each alarm, but during the past two years a motor is not started unless more than about 100-lb. pressure is called for. Under present operating conditions the two stations combined only operate on about 121 fires per year. The practice of running each motor once each day for about five minutes has also generally been followed in Brooklyn.

Failure of Insulation of Three Motors in the Main Brooklyn Station. On August 20, 1917, there was a fire in Brooklyn, and after the station had been in operation for about forty-eight minutes one of the motors burned out. A second motor was started and ran for forty-two minutes, when it burned out; and a third motor was started and ran for sixty-six minutes, when it also burned out. A fourth motor finished the run on this fire, which required it to be in operation for about forty-five minutes. An examination showed that the insulation of the stators had

failed, and that they would have to be rewound. This work was done by the General Electric Company at a total cost of $5 305, the greater part of the work being done at the station. The order to make the repairs was given in August, 1917, and the repairs were not completed until December, 1917. One of the three motors developed a short circuit in its rotor when it was being tested after repairs, and this damage required two months to effect the repairs, and cost $2 120.45. It seems probable that the failure was due partly to the natural deterioration of the insulation from age, combined with severe conditions due to infrequent operation and high moisture. To minimize the danger of a repetition of failure from this cause, orders were given to run each motor for not longer than thirty minutes, and then change over to a fresh motor. Tests made at this time on the remaining machines at the Joralemon Street station showed insulation resistances from 1 to 1.8 megohms cold. Insulation resistances, measured warm, after twenty hours' baking by direct current of approximately full load amperage, sent through the stator coils, measured 0.7 to 1.8 megohms. These same machines showed 4 to 6 megohms cold.

This baking process was continued for about one week, at the end of which time the resistance cold measured from eight to ten megohms. The resistance warm, however, would drop to slightly under two megohms. It may be remarked that the weather conditions for the month of August, 1917, were relatively favorable, the humidity being considerably below and the sunshine considerably above normal. These machines were baked and varnished in January, 1918, after which the resistance measured some 300 megohms. In the summer of 1918, however, some eight months after the machines were baked and varnished, the insulation resistance dropped to slightly under two megohms on days when the weather conditions were unfavorable. In the spring of 1919, the writer's attention was called to the tendency for this insulation resistance to fall, and tests were made to overcome this by the application of external heat to the windings.

Inquiry of the manufacturers showed that they considered a minimum of five megohms resistance as necessary for safety of

operation, although operating men of experience gave their opinion that two megohms would be sufficient.

During the nine days of rain in July, tests were made in Manhattan and Brooklyn, which showed a resistance as low as 0.4 megohm on some motors. It is evident that the motors absorbed moisture from the air in sufficient volume to lower the insulation resistance to a dangerous degree, and that the operation of a motor still further increases this reduction in resistance and endangers the continuance in service of a motor in case it is required for fire use. Such a condition manifestly could not be permitted to continue, and it therefore became necessary to promptly determine the steps to be taken to secure an effective remedy.

Measures Taken to prevent Reduction in Insulation Resistance. It is evident that it is necessary to expel the moisture present in the insulation, and then either maintain a dry air around the motors, or else expel moisture from the motors at such intervals as might be found necessary to maintain a safe resistance. As far as could be determined, during the period when the stations were artificially heated, the resistance was reasonably high, but there is not sufficient evidence to be conclusive on this point. It was decided to try various devices, such as covering each motor with a canvas housing, which could readily be removed by one man in case the motor was needed for service, and apply heat, using a small steam coil at the base of the motor frame. The canvas cover is to be made so that circulation of air through openings can be secured if desired, and it is believed that the canvas hood and steam coil will prove effective. Whether heat will be applied continuously or intermittently will be determined by experiment. A meggar outfit has been requisitioned for use mainly to test these motors, and in the future regular as well as special tests will be conducted.

Consideration was given to the use of unheated air, dried by means of a special electric fan or blower, and this method offers interesting possibilities which may later be tried out by tests, but for the present the drying of the air by heating seems to be the surest in its results.

The writer believes that there are enough electric motor instal-

lations in connection with water plants to make the subject of the lowering of insulation resistance by moisture of interest to a number of operating superintendents, and trusts that the experience of others will be set forth for the guidance of all.

PROCEEDINGS.

June Meeting.

Hull, Mass., June 25, 1919.

The June meeting of the New England Water Works Association was held at Pemberton Inn, Hull, on June 25, 1919.

The following members and guests were present:

Honorary Members.

F. E. Hall.
R. J. Thomas. — 2.

Members.

F. S. Bailey.
F. A. Barbour.
J. F. Barrett.
T. J. Carmody
J. E. Conley.
J. H. Dillon.
J. M. Diven.
Frank Emerson.
G. E. Evans.
G. H. Finneran.
F. L. Fuller.
F. J. Gifford.
A. F. Hart.
D. A. Heffernan.
H. W. Horne.
W. F. Hunt.
D. D. Jackson.
Willard Kent.
J. A. Kienle.
S. E. Killam.
F. A. McInnes.
Hugh McLean.
H. V. Macksey.
J. H. Mendell.
G. F. Merrill.
Leonard Metcalf.
H. A. Miller.
F. L. Northrop.
H. E. Perry.
G. A. Sampson.
G. G. Shedd.
J. F. Sullivan.
H. A. Symonds.
J. A. Tilden.
S. E. Tinkham.
E. J. Titcomb.
J. H. Walsh. — 37.

Associates.

Bond, Harold L., Co., by H. C. Bond.
Byers, A. M. Co., by H. F. Fiske.
Donaldson Iron Co., by C. F. Glavin.
Eddy Valve Co., by H. R. Prescott.
Edson Mfg. Co., by H. L. B. Watson.
Engineering and Contracting, by R. E. Brown.
Engineering News-Record, by I. S. Holbrook.
Gamon Meter Co., by R. J. Thomas.
Hersey Mfg. Co., by W. A. Hersey, J. H. Smith.
Pittsburgh Meter Co., by G. C. Northrop.
Rensselaer Valve Co., by I. A. Rowe, C. L. Brown.
Smith, A. P. Mfg. Co., by F. L. Northrop.
Thompson Meter Co., by E. M. Shedd.
Union Water Meter Co., by H. L. Jacobs.
United Brass Mfg. Co., by G. A. Caldwell.

Ludlow Valve Mfg. Co., by A. R. Taylor.
Mueller, H., Mfg. Co., by C. J. G. Haas.
National Meter Co., by J. G. Lufkin, H. L. Weston.
Pitometer Co., by E. E. Case.
United States Cast Iron Pipe & Foundry Co., by W. P. Mosteller.
Water Works Equipment Co., by W. H. Van Winkle.
Wood, R. D., & Co., by R. M. Simon.
Worthington Pump & Machinery Co., by Samuel Harrison. — 26.

GUESTS.

MASSACHUSETTS.

Boston, Carl S. Ell, Mary E. Evans, Carroll A. Farwell, Arthur L. Gammage, Miss Joan M. Ham, E. R. Simpson, Samuel E. Stott, Mrs. J. A. Tilden, Lester W. Tilden, Mrs. S. E. Tinkham.
Cambridge, Eugene F. Sullivan.
Canton, Charles N. Reynolds.
Chicopee, Peter C. Garrity.
Cliftondale, Mrs. A. F. Hart.
Dedham, Allan T. Gifford.
Greenfield, Major Elwin S. Warner.
Holyoke, Mrs. T. J. Carmody, Mrs. J. H. Dillon, Miss Helen Hanley, Miss G. Sullivan, Miss Marion McLean.
Lynn, Mr. and Mrs. F. G. Berry, Dorothy B. Carpenter.
Needham, Mr. and Mrs. C. S. Bryer.
Norwood, Carl B. Reed.
Peabody, Joseph A. Ryan.
Somerville, James E. Stone.
Waban, David Sutton.
Waltham, Frank L. Preble.
Watertown, John N. Cashman.
Wellesley, Francis P. Hersey, Winthrop P. Hersey.
Winchester, H. W. Dotten.
Winthrop, Mr. and Mrs. O. D. Rice.
Woburn, Hon. W. E. Blodgett.
Wollaston, Edwin F. Allbright, Mrs. J. H. Smith, Ellsworth Smith.

RHODE ISLAND.

Bristol, J. M. Jones.
Narragansett Pier, Mrs. Willard Kent.

NEW YORK.

New York City, C. B. Hayward, Mrs. W. H. Van Winkle.

NEW JERSEY.

Elizabeth, Mr. and Mrs. C. N. Bingham. — 47.

The Secretary presented applications for membership, properly endorsed by the Executive Committee.

The Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared elected.

Hon. W. E. Blodgett, ex-mayor of Woburn, Mass., gave a very interesting talk on the welfare work among our boys at the rest camps in France.

Adjourned.

WILLARD KENT, *Secretary.*

THIRTY-EIGHTH ANNUAL CONVENTION.

ALBANY, N. Y.,
September 30, October 1, 2, 3, 1919.

The thirty-eighth annual convention of the New England Water Works Association was held at Albany, N. Y., September 30, October 1, 2, and 3, 1919.

The sessions of the convention were held at the Hotel Ten Eyck, where also were provided accommodations for the exhibits of Associates.

The following members and guests were present:

HONORARY MEMBERS.

Rudolph Hering. G. A. Stacy. R. J. Thomas. — 3.

MEMBERS.

G. H. Abbott.
D. L. Agnew.
S. A. Agnew.
M. N. Baker.
L. M. Bancroft.
F. A. Barbour.
W. T. Barnes.
G. W. Batchelder.
G. H. Bean.
F. E. Beck.
James Bedell.
G. A. Benjamin.
F. D. Berry.
A. E. Blackmer.
George Bowers.
Bertram Brewer.
H. A. Burnham.
A. N. Burnie.
J. M. Caird.
T. J. Carmody.
A. M. Chaffee.
C. E. Chandler.
A. T. Clark.
E. S. Cole.
William Colquhoun.
W. R. Conard.
H. R. Cooper.
G. K. Crandall.
H. C. Crowell.
John Cullen.
F. A. Darling.
D. A. Decrow,
J. H. Dillon.
J. M. Diven.
R. L. Dobbin.
J. S. Dunwoody.
E. D. Eldredge.
R. H. Ellis.
Frank Emerson.
A. B. Farnham.
S. F. Ferguson.
G. H. Finneran.
M. E. FitzGerald.
A. P. Folwell.
B. E. Fox.
E. V. French.
F. L. Fuller.
F. C. Gamwell.
Patrick Gear.
H. T. Gidley.
F. J. Gifford.

T. C. Gleason.
H. J. Goodale.
F. W. Gow.
F. W. Green.
D. R. Gwinn.
L. M. Hastings.
W. C. Hawley.
C. B. Hayward.
D. A. Heffernan.
R. E. Horton.
A. C. Howes.
W. F. Hunt.
G. A. Johnson.
J. M. Jones.
J. W. Kay.
F. T. Kemble.
T. R. Kendall.
Willard Kent.
S. E. Killam.
G. A. King.
H. C. Kinney.
John Knickerbacker.
Morris Knowles.
Paul Lanham.
T. F. Lawlor.
M. B. Litch.
B. C. Little.
F. F. Longley.
F. H. Luce.
P. J. Lucey.
S. H. MacKenzie.
W. A. McKenzie.
D. B. McCarthy.
J. R. McClintock.
H. S. R. McCurdy.
J. A. McKone.
E. T. McDowell.
Hugh McLean.
W. H. McMahon.
H. V. Macksey.
A. E. Marton.
W. P. Mason.
H. P. T. Matte.
E. E. Miller.
M. L. Miller.
J. W. Moran.
F. A. Nagler.
E. B. Norton.
J. A. Newlands.
W. H. O'Brien.
W. J. Orchard.
Alexander Orr.
C. E. Peirce.
A. E. Pickup.
J. F. Reagan, Jr.
J. H. Remick.
J. L. Rice.
R. M. Roper.
G. A. Sampson.
H. W. Sanderson.
C. M. Saville.
F. W. Schwartz.
W. P. Schwabe.
C. W. Sherman.
R. W. Sherman.
J. Waldo Smith.
G. H. Snell.
S. B. Story.
J. F. Sullivan.
W. F. Sullivan.
Russell Suter.
S. A. Sweell.
E. A. Taylor.
S. H. Taylor.
J. A. Tilden.
A. H. Tillson.
D. N. Tower.
Louis Trial.
W. J. Turnbull.
Lincoln Van Gilder.
L. M. Wachter.
I. S. Walker.
J. H. Walsh.
H. T. Wheelock.
J. F. Whitney.
I. S. Wood.
C. L. Wooding.
L. C. Wright. — 139.

ASSOCIATES.

American City, The, by L. P. Anderson.
Builders' Iron Foundry, by J. D. Purdue, G. H. Lewis, A. B. Coulters, and F. N. Connet.
Byers, A. M. Co., by C. F. Uhler, H. F. Fiske, and J. J. Riley.
Carbic Mfg. Co., by E. G. Frey.
Central Foundry Co., by R. W. Conrow and Stuart Root.
Dixon Crucible Co., by L. M. Chase.
Badger Meter Mfg. Co., by W. S. Cetti.
Eddy Valve Co., by H. A. Holmes and F. S. Robinson.
Electro Bleaching Gas Co., by J. A. Kienle and S. W. Jacob.
Engineering and Contracting, by R. E. Brown.
Engineering News-Record, by H. M. French, Wm. Buxman, Wm. Van Kluck, I. S. Holbrook, and R. K. Tomlin.
Fire and Water Engineering, by K. M. Mann, R. H. Lockwood, and W. J. Berger.

Ford Meter Box Co., by E. H. Ford.
Gamon Meter Co., by R. J. Thomas.
Hays Mfg. Co., by F. F. Myers and A. R. Johnson.
Hersey Mfg. Co., by J. H. Smith and W. C. Sherwood.
Leadite Co., The, by George McKay, Jr.
Lead Lined Iron Pipe Co., by T. E. Dwyer.
Lock Joint Pipe Co., by H. E. Pride.
Ludlow Valve Mfg. Co., by A. R. Taylor, J. H. Caldwell, and Harold Burgess.
Mueller Mfg. Co., by C. J. G. Haas and James Mashell.
Municipal Journal and Public Works, by S. N. Hume.
National Meter Co., by J. G. Lufkin and H. L. Weston.
National Tube Co., by H. T. Miller.
National Water Main Cleaning Co., by B. B. Hodgman.
Neptune Meter Co., by T. D. Faulks, W. H. McGarry, Jr., Chas. Bachmann, and J. R. Van Gorder.
N. Y. Continental Jewell Filtration Co., by A. W. Crane and A. L. Solleder.
Norwood Engineering Co., by H. N. Hosford.
Pitometer Co., The., by E. D. Case.
Pittsburgh Meter Co., by G. C. Northrop, V. E. Arnold, J. W. Turner, and J. J. Salmond.
Rensselaer Valve Co., by I. A. Rowe and C. L. Brown.
Ross Valve Mfg. Co., by William Ross.
Smith, A. P. Mfg. Co., by D. F. O'Brien, A. C. Nieman, T. F. Halpin, and F. L. Northrop.
Taylor, W. P. Co., by P. J. Weigel.
Thomson Meter Co., by H. F. Hoyt, J. L. Atwell, E. M. Shedd, and F. M. Watson.
S. E. T. Valve and Hydrant Co., by C. L. Lincoln.
Union Water Meter Co., by D. K. Otis, E. W. Jacobs, and H. W. Jacobs.
United Brass Mfg. Co., by G. A. Caldwell, W. N. Fairfield, and H. M. Flemming.
United States Cast Iron Pipe and Foundry Co., by W. P. Mosteller.
Wallace & Tiernan Co., Inc., by M. F. Tiernan, R. V. Donnelly, and A. Johnstone.
Water Works Equipment Co., by W. H. Van Winkle.
R. D. Wood & Co., by C. R. Wood and R. M. Simon.
Worthington Pump and Machinery Corp., by Samuel Harrison and C. C. Brewster. — 85.

GUESTS.

MAINE.

Auburn, Mr. and Mrs. A. W. Cobb.
Castine, Mrs. G. A. Benjamin.
Freeport, Mrs. D. E. Roelick.

NEW HAMPSHIRE.

Claremont, Mrs. J. L. Rice.
Derry, George G. Bean.
Nashua, Frank B. Clancy.
Tilton, Mrs. E. Hill, Mrs. C. J. Morse, and Mrs. C. Varnum.

MASSACHUSETTS.

Boston, Mrs. W. T. Barnes, Master Wellington T. Barnes, Miss Joan M. Ham, Mrs. S. E. Killam, Mr. and Mrs. R. M. Kinsman, C. B. Moore, Mrs. J. A. Tilden, Lester W. Tilden, and A. M. Thomson.
Cambridge, Mrs. L. M. Hastings.
Chelmsford, Mrs. W. H. McMahon.
Chicopee, Edward C. Frazier, Peter C. Garrity, and James J. Page.
Cohasset, Mrs. D. N. Tower and Miss B. L. Tower.
Dedham, Mrs. F. J. Gifford, Allan T. Gifford, Mrs. T. Piercy, and Harry R. Wragg.
Fall River, James J. Kirby and A. J. Brunette.
Franklin, Henry J. Cockell.
Haverhill, Mrs. H. C. Crowell.
Holyoke, Leo W. Beacon, Mr. and Mrs. Wm. Brick, Mrs. T. J. Carmody, Mrs. J. H. Dillon, and Elsie McLean.
Littleton, Mrs. J. H. Remick.
Lowell, Alton R. Bowers, Mrs. W. F. Hunt, Mr. and Mrs. George Marchand, Charles J. Morse, and Mrs. R. J. Thomas.
Malden, Fred M. Prescott.
Marlboro, Mrs. G. A. Stacy.
Medford, Mrs. F. W. Gow.
Milford, Mrs. J. W. Kay and Miss I. T. Nelson.
Milton, Mrs. D. A. Heffernan.
Oxford, Mrs. A. M. Chaffee, Lester J. Chaffee, Sarah Chaffee, and Hazel G. Foster.
Palmer, Mrs. F. C. Gamwell.
Peabody, Mrs. Frank Emerson.
Pittsfield, Mrs. A. B. Farnham and Frank Martineau.
Plymouth, Mrs. A. E. Blackmer.
Southbridge, Mrs. G. H. Abbott.
Southampton, Mrs. C. D. Powers.
Springfield, Charles W. Winslow.
Waltham, Mrs. Bertram Brewer and Mrs. E. A. Moulton.
Ware, Mrs. J. E. Gleason.
Westfield, Alfred O. Sanford.
West Springfield, I. T. Alstrom, Mr. and Mrs. G. N. Norris, and Mrs. J. F. Whitney.
Winthrop, Harry A. Ford.
Woburn, Mrs. H. V. Macksey.

RHODE ISLAND.

Narragansett Pier, Mrs. Willard Kent.
Providence, Mrs. I. S. Wood.
Woonsocket, Miss Catherine Mullaney.

CONNECTICUT.

Bristol, Mrs. C. L. Wooding and Helen Wooding.
East Hartford, Mrs. J. H. Walsh.
Hartford, Mr. and Mrs. S. H. Berry, John Carlson, J. T. Carmody, Martin Cannon, J. J. Donneley, J. J. Dennehy, E. L. King, E. D. Magens, Arthur J. McManen, Mrs. C. M. Saville, D. F. Sullivan, Humphrey Sullivan.
New London, Mrs. G. K. Crandall.
Norwich, Mrs. C. E. Chandler.
Southington, Mrs. S. H. MacKenzie, Miss Eunice MacKenzie, Miss Fannie MacKenzie, and Daniel F. Shanahan.
Unionville, Charles A. Hackney.
Wallingford, Mrs. W. A. MacKenzie.

NEW YORK.

Albany, Louise Anderson, J. H. Brewster, E. S. Chace, Mrs. Wallace Greenalch, Mrs. Theodore Horton, Alex R. McKim, Frank B. Northrop, G. B. Nichols, Miss E. H. Sherman, and James Wyllie.
Buffalo, Mrs. P. J. Weigel.
Cambridge, Mrs. Eliot B. Norton.
Cohoes, Edward Hayes.
Glens Falls, G. M. Doughy.
Mamaroneck, Mrs. R. E. Brown.
New York, Homer N. Calver, Harry Gardner, Mrs. C. L. Lincoln, Mrs. D. B. McCarthy, E. G. Reynolds, Jr., Franklin Van Winkle, and Mrs. Walter Van Winkle.
Poughkeepsie, Elbert W. Sylverter.
Rensselaer, Mr. and Mrs. C. R. Claflin.
Stapleton, W. Volkhardt.
Troy, Mrs. F. S. Bates, James A. Beatie, Mrs. Fred Bowen, Hon. C. F. Burns, Mrs. James M. Caird, Mr. and Mrs. C. E. Clixton, H. M. Dibert, Miss C. S. Edgley, Mrs. W. C. Feathers, Mrs. E. F. Peakes, Palmer C. Ricketts, A. E. Roche, Mrs. I. A. Rowe, M. W. Shaughnesy, and Mrs. J. B. Wilbur.
Wappingers Falls, F. J. Bain.
Watervliet, Mr. and Mrs. C. S. Keating.
Yonkers, Mrs. Wm. Colquhoun and Mr. and Mrs. Thomas H. See.

NEW JERSEY.

Atlantic City, Mrs. Lincoln Van Gilder.
Asbury Park, Mr. and Mrs. C. H. White and Miss Geraldine White.
Little Falls, Mrs. F. W. Green.
Maplewood, Mrs. W. J. Orchard.
Madison, Herbert K. Saxe.
East Orange, Mrs. R. M. Roper.

PENNSYLVANIA.

Philadelphia, E. M. Nichols and Mrs. C. R. Wood.
Scranton, W. A. Wilcox.

MARYLAND.

Lanham, Mrs. Paul Lanham, Paul T. Lanham, and Helen Wood.

WEST VIRGINIA.

Morgantown, G. H. Bayles.

ILLINOIS.

Mattoon, G. W. Bailey.

CANADA.

Toronto, Mr. and Mrs. N. J. Howard.
— 169.

Morning Session, Tuesday, September 30, 1919.

The convention was called to order at 10 A.M. by Mr. Russell Suter, chairman of the Committee on Local Members. In opening the convention Mr. Suter spoke as follows:

Mr. Suter. Before proceeding with the regular business of the convention the Association will be welcomed to Albany. The city which welcomes us has been so democratic as to elect this year as its mayor an engineer and contractor. I take great pleasure in presenting to you the Hon. James R. Watt, mayor of Albany. [*Applause.*]

Address of Welcome by Hon. James R. Watt.

Mr. Chairman, Ladies, and Gentlemen, — It is indeed a pleasure to be here this morning to welcome you delegates to the little old city of Albany. I say " old " city, because it is the second oldest incorporated city in the United States. We are very proud of Albany; we are very proud to call this a convention city. During the past year and a half under my administration and the new Chamber of Commerce, both working together, we have striven to make it a convention city, and we have been successful. We therefore appreciate all the conventions that can be brought here, and gladly welcome each and every one of you to the city. While you are here we want you to feel free and easy to take in all the sights. We have many historical sights here. And to the ladies particularly I would suggest that if possible they take in the Educational Building, which will entertain them easily for a whole day, if they can spare that time.

The chairman has said that I am an engineer and contractor. I should like to correct that by saying that I am a contractor and half an engineer. But I appreciate the troubles engineers have, and I also appreciate, and no doubt you do, that the work which you have before you now — principally water — is an all-absorbing topic at the present time; has been since July 1. [*Laughter.*] And it probably will continue to be for some time to come. Water, of course, has been considered a food product; now it will be a food and beverage.

Do not hesitate on our water. We are proud of our water system. We have, we think, as fine a water system as there is in the country. I understand that you are going to inspect the system, and I hope that you will agree with us on the conclusion of that trip that our judgment is correct. We feel that our water here is a little better than Ivory soap, which is advertised as 99.44. Our chemists say our water is 99.90.

Now, seriously, we do welcome you, each and every one of you, to the city, and I sincerely hope that your visit here will be one of pleasure and profit, not only to yourselves but to the city of Albany. I thank you. [*Applause.*]

Mr. Suter. Not only are we the guests of the city of Albany, but many courtesies have been shown to us by the Chamber of Commerce. The Chamber of Commerce will welcome us, represented by the secretary-manager, Mr. Roy S. Smith. [*Applause.*]

Address of Welcome by Mr. Roy S. Smith.

Mr. Chairman, Ladies, and Gentlemen, — The Mayor has presented to you the formal and official welcome from the city; I desire to extend to you, in coöperating with him and supporting him, the official welcome of the civic organization, the Albany Chamber of Commerce. The Mayor could have spoken as well for the Chamber of Commerce, because it so happens that he is a member of the board of directors of the Albany Chamber of Commerce, and so while I am on behalf of the board of directors speaking to you, I am also coöperating with one of my bosses who is a member of the board.

It is true that the Chamber of Commerce and the City Administration have worked in perfect harmony for the development of this magnificent community. And on behalf of our organization — which I am very pleased to say to those ladies who are present numbers nearly one hundred women members — we extend to each and every one of you a very cordial welcome to this city, of which we are so proud. If any of you like it so well while you are here that you desire to change your addresses, you will find our offices down in the corner of this building, where we will be very glad to make arrangements to permanently locate you here. While

we know that you are all loyal citizens of your communities, yet we desire while you are here to make you feel perfectly at home in Albany.

It will interest you to know that the first steam railroad train which operated in the world started its trip from this city. The first long-distance aëroplane trip in the world started from Albany to New York City, when Glenn Curtiss made the famous ride down the Hudson River. And at the present time the Albany Chamber of Commerce, working with the City Administration, has established the first aëroplane landing field in the United States. It was here that the first electric spark was invented which ultimately made possible the telegraph and the electric motor. And here we have a community which we are very proud to say contains one hundred per cent. Americans.

Albany, as the Mayor said, is the second oldest incorporated city in the United States, having been incorporated in 1686. It is the third largest mail transfer point in the United States; it is the second largest express transfer point in the United States, excelling both New York and Philadelphia in those two particular points. There are so many things for you to see here that it is difficult for me, as a member of the Chamber of Commerce, to see how you are going to see them all; but I want you to do your best.

I feel you are just a little in the position of a colored soldier friend of mine who was in camp down on Long Island. He had served his first week out, and it came Saturday night, and time for him, as he supposed, at the end of a week, to go home. Concluding his week's work with Uncle Sam he laid down his rifle and started to go home. Arriving at the gate he was challenged by the sentry, who said, "You can't go out here." "Why not? my week's work am done." "You haven't any pass; you can't go by here"; and he pointed his bayonet at the soldier. The colored soldier reached down and pulled out a razor, which he commenced to strop on his boot-leg, saying, "I have a mother in heaven, a father in hell, and a girl in Harlem; I am going to see one of them three to-night." [*Laughter.*]

Now, there are a great many things of interest for you to see in Albany, and while I know it will be impossible for you to see them all, I ask you to go as far as you can and consider the city is yours.

The offices of the Chamber of Commerce are on the ground floor of the Ten Eyck Hotel. Everything that we have there, including writing materials, will be at your disposal. The more the members of your convention take advantage of the Chamber of Commerce, the more pleased we will be.

I understand there has been arranged an entertainment program for you. I am authorized by Mr. Winchester, president of the Woolferts Roost Country Club, to invite each and every one of you to make use of the privileges of the club, which are at your disposal while you are in the city.

If any of you get in trouble, the Mayor will be at the telephone at his office and will see to it that you get out of that trouble.

Seriously, we are very glad you are here. Our entire facilities are at your disposal, and I should like you to appreciate that this city is noted for its wealth of hospitality and the warmth of its greeting. [*Applause.*]

Response by President Samuel E. Killam.

Mr. Mayor and Gentlemen of Albany, — The warmth of your reception has deeply impressed me. We anticipated a generous welcome at your hands, for the fame of your hospitality has been generally known among our members.

Although this is our first visit to Albany as an Association, we have heard of your city historically, commercially, politically, and socially, and know that your city keeps abreast of the improvements and demands of the age.

We fully appreciate the genuine heartiness of your welcome and the excellent rooms that have been provided for our meeting, and we know that under your guidance we shall greatly enjoy our stay in your beautiful city.

Gentlemen of the city of Albany, in the name of the New England Water Works Association, it gives me the greatest pleasure to thank you again for your kind words and cordial greetings.

Address by President Samuel E. Killam.

Fellow-Members of the New England Water Works Association and Guests, — The thirty-eighth annual convention of the New England Water Works Association meets to-day in this beautiful

city of Albany, where the first league of the colonies was proposed by Benjamin Franklin in 1754. This plan was rejected by the British crown because it gave too much power to the colonies, and by the colonies because it gave too much power to the crown. The significance of this congress lies in the fact that it stimulated the union of the colonies which afterwards became a reality.

I do not propose to dwell unduly upon the problems that confront us in this reconstruction period, which is now in the making after the close of the greatest war in the history of the world. The war is over, although the treaty of peace has not been ratified. Let us hope that whatever the final agreement may be it will prove as beneficial to the United States as resulted from the rejection of the league of the colonies by both parties in 1754.

We are passing through a period of unrest. The whole social structure of governments has been shaken and our own democratic government has not entirely escaped. Our own Association has felt this unrest perhaps no more than other similar organizations, but the cause of this must be found and mastered. We are water-works men, and meet primarily to consider matters pertaining to water supplies; but are we meeting the individual needs of our members?

Our founders — who builded better than they knew — may well look back with pride on the work that has been accomplished, but do the original aims satisfactorily meet our individual needs of to-day?

In this serious period let us not forget that the Association is in our hands, to be molded as we choose. Is it not well to cultivate our neighbors and enter upon all problems with open minds and in the spirit of coöperation? A careful consideration of our own particular needs will cause to increase our security in water-works fraternity.

If we are to continue to grow we must meet the individual needs of the practical water-works man. We must stand behind every superintendent in his endeavor to fulfill his office in an honest, capable, and efficient manner. The individual must feel that the strength of the Association is behind him to aid him in every honest effort that he may make to better the community that he serves.

There are many problems that the modern water-works executive must meet. Among them is the introduction into the state legislatures of bills that, if enacted, would become a serious menace to public health. Individual efforts in such matters are not adequate. It is necessary for members to get together and, with the co-operation of similar organizations, see to it that the members of the legislature realize the heavy personal responsibility which rests upon them in passing measures that would lower the standards and jeopardize the public health for the pleasure of the few. I believe that it would be well to have a committee in all of the thirty-seven states in which we have members to watch for the introduction of such bills in state legislatures and report to the Executive Committee of the Association in order that this Association may be on record as against any legislation that tends to lower the standards and injure the public health of the state.

Our permanent headquarters have been of great benefit to the Association, but I believe that the force should be reorganized so that it will be of practical use to individual members, and thus make the New England Water Works Association a strong, influential body. The office at headquarters should be the source of all water-works information. Such, however, cannot be fully realized without a sufficiently paid local secretary. Our resources at the present time are such, however, as not to permit of the reorganization of the office force on this basis. I think that you will all agree with me when I say that some executive officers should be in personal touch with headquarters. In making this suggestion no reflection is cast upon our faithful Secretary, who, on account of his home location, finds it impossible to give his personal attention to headquarters. If the present organization is to continue, I suggest that the office of assistant secretary be created in order that a member may be in touch with work at headquarters, assist in research work of committees, and that all matters pertaining to the Association be suitably filed and indexed. In this way I believe that a foundation could be built which would be immovable.

The budget system, which on the whole has worked very well, is now being adopted by states, municipalities, private concerns, and even organizations similar to our Association. Detailed estimates of sums required for various expenditures are made

previous to the beginning of the fiscal year. I believe that it is advisable for this Association to make a study of its finances in view of putting such a system into practice in 1920. I would recommend that our Finance Committee, or a special committee, take up this problem and report their findings to the Association not later than our December meeting.

I also recommend that a committee be appointed to make a study of our constitution and by-laws, to ascertain if there are any changes or additions that it seems desirable to make before the publication of the 1920 year-book.

I believe that it is necessary for us to expand if we are to maintain our place among the technical societies of our country. There has been no serious loss in membership; neither has the membership increased as rapidly as is desirable. How can we grow in numbers and still be healthy? I know of only one way, and that is to arouse the individual to the sense of the responsibility that rests upon him to extend the good influences of the Association.

I believe that the New England Water Works Association will take the initiative and maintain its enviable record of usefulness through its excellent work of special committees. It is desirable to coöperate with similar organizations in order to produce fewer conflicting standards. Next in importance to coöperation of committees between societies are conferences between committees and manufacturers on specifications for supplies used in water-works construction. The presence of a representative of the manufacturers at such committee hearings is an indication that we are broadminded enough to look beyond our own border and consider the general progress of established industries.

To-day we meet in convention. Let us be punctual in attendance upon the meetings, and may earnestness of purpose characterize the sessions.

We welcome those who have been in the service of our country during the past months, and extend to them our heartfelt esteem for the manner in which they have performed their valuable service when the country was sorely in need of trained men.

We welcome the families and friends of our members to this convention. May they find pleasure in attending our sessions as well as the excellent entertainments provided for them.

I wish particularly to thank the various convention committees for their able and painstaking work, and the Water Works Manufacturers Association for their generous support of the convention.

We are indebted to many, and to all we return thanks.

In conclusion I wish to say that what we need primarily is individual service for the practical water-works operators in order that we may grow and develop as an association. Let us enter upon our work in the spirit of coöperation for higher ideals, better service, and the best interests of the New England Water Works Association. [*Applause.*]

MR. THOMAS J. CARMODY. If I may be permitted to say it, I think we ought to pass a vote of thanks for the document just read by our President.

I would move, if in order, that a vote of thanks be extended to our presiding officer for the very able paper which he has read, giving an outline of the work of this Association for the past year.

(The motion was duly seconded, and the question was put by Secretary Kent and carried unanimously.)

AWARD OF DEXTER BRACKETT MEDAL.

President Killam in the chair.

PRESIDENT KILLAM. The first thing on our program is the presentation of the Dexter Brackett Memorial Medal. I will ask Mr. Barnes, chairman of the committee, to step forward, and also Mr. David A. Heffernan.

MR. WILLIAM T. BARNES. *Mr. President, Members of the Association, and Friends,* — It was about twenty-five years ago that I first had the pleasure of attending a New England Water Works convention, in Boston. Of the members present at that time,— aside from our revered friend, Mr. Coggeshall, whom I had known before, — the one person whom I remember more particularly than any one else was Dexter Brackett.

Dexter Brackett at that time was comparatively young, and he showed a keen interest in this Association by giving it his individual support in the work of important committees and by presentation of papers.

It is fitting that his friends and associates should have established

as a memorial to Dexter Brackett the award of a medal to be known as " The Dexter Brackett Memorial Medal," to be awarded each year for the most meritorious paper delivered during the preceding year. It falls to me, as chairman of the Committee on Awards, to make the announcement of this award for the most meritorious paper during the year 1918.

It was not an easy task for the members of that committee to decide this question, but I am glad to say that by a unanimous vote it was decided that Mr. David A. Heffernan, superintendent of water works at Milton, in the delivery of his paper entitled, " Practical Methods for Detecting Leaks in Underground Pipes," was entitled to the medal for the year 1918. [*Applause.*]

It is needless for me to say more, Mr. Heffernan, in presenting this medal to you. The paper speaks for itself. It gives me great pleasure, therefore, to make this award. [Handing medal to Mr. Heffernan.] [*Applause.*]

Mr. David A. Heffernan. *Mr. President and Members,* — Really, I am surprised. I do not know what to say; I never expected anything like this. But I want to thank the Association, also the committee, for their generous gift. I think that every superintendent interested in water works should try to keep up the best interests of the Association, bringing forth papers, and so forth, so as to keep the work of the Association up to standard. I will say that I shall try always to work for anything that comes up that will be any improvement, and if there is anything that I can do to be of assistance I shall be glad to do it. I thank you.

Mr. Patrick Gear. In regard to the awarding of this medal to Mr. Heffernan, I hope that the superintendents all over New England will realize that they have a chance to get this medal themselves at some future time. When the giving of a medal was first proposed we all thought that nobody would ever get the medal but an engineer. I am glad to say that this has not been the case. An engineer got the first one, a water adjuster got the second one, and a practical superintendent has now gotten the third one. So that we are now even with the engineers, and it is up to the superintendents to see if they can't beat them right along.

President Killam. I might say that without doubt this is a genuine surprise to Mr. Heffernan. The award was made by the

Executive Committee recently, who saw fit not to tell Mr. Heffernan until they got him here on the floor.

The Secretary read the following names of applicants for membership, all of whom had been approved by the Executive Committee, and they were duly elected:

Active: Charles R. Barker, Boston, Mass., engineer, New England Insurance Exchange; Samuel A. Sewell, St. John, N. B., superintendent, Water and Sewerage Department; John S. Caldwell, Boston, fire protection engineer; John A. McKone, Hartford, Conn., president Board of Fire Commissioners; Francis W. Collins, New York City, consulting engineer; Francis J. Seery, Ithaca, N. Y., hydraulic engineer, U. S. Geological Survey; Francis C. Millspaugh, Lowell, Mass., hydraulic engineer; Irving H. Henderson, Cambridge, Mass., foreman Meter Department, Cambridge Water Works; Jno. F. Laboon, Pittsburgh, Pa., civil engineer; Eliot B. Norton, Cambridge, N. Y., superintendent water works. — 10.

Associate: Flower Valve Manufacturing Co., Detroit, Mich., manufacturers hydrants, valves, etc.; *Engineering and Contracting*, Chicago, Ill.; *Municipal Journal and Public Works*, New York City; New York Continental Jewel Filtration Company, Nutley, N. J., manufacturers of gravity and pressure filters. — 4.

Roosevelt Memorial Resolution.

The Secretary then read a communication from the Roosevelt Memorial Association, suggesting the adoption by the New England Water Works Association of the following resolution:

" *Whereas*, the Roosevelt Memorial Association has been formed by the friends of the late Col. Theodore Roosevelt to honor his memory; and

" *Whereas*, the Roosevelt Memorial Association aims to provide memorials in accordance with the plans of the National Committee which will include the erection of a suitable and adequate monumental memorial in Washington; and acquiring, development, and maintenance of a park in the town of Oyster Bay which may ultimately, perhaps, include Sagamore Hill, to be preserved like Mount Vernon and Mr. Lincoln's home at Springfield; and

" *Whereas*, the Roosevelt Memorial Association announces a national campaign for funds in the week of October 20–27; and

" *Whereas*, the sum of five million dollars is to be raised through the subscription of millions of individuals;

" Therefore, be it

" *Resolved*, that.............................recognizing his superlative Americanism and his inestimable services to our

nation as citizen and statesman, hereby records its hearty endorsement of the plans of the Roosevelt Memorial Association and pledges its support to the national campaign to be conducted by that Association."

MR. FRANK L. FULLER. I move, Mr. President, that the resolution be adopted.

(The motion was seconded.)

MR. H. V. MACKSEY considered the resolution somewhat indefinite, and called attention to the obligation of the Association if a formal endorsement were given. He also spoke of the limited means of the Association, the numerous calls for financial response for numerous worthy public purposes, and counseled that further consideration be given before the Association committed itself in this manner.

Mr. Macksey favored individual subscriptions rather than an Association subscription.

MR. RICHARD W. SHERMAN concurred in the views of Mr. Macksey, and while expressing the greatest admiration for Colonel Roosevelt, and referred to statements that he was the greatest man America ever produced, favored individual subscriptions, and questioned if the Association should properly make a contribution for a purpose of this kind.

MR. HUGH MCLEAN called attention to the numerous demands for funds for worthy causes, and while he personally wished to give his strongest support to any proper measure in honor of the late President Roosevelt, he did not favor a direct contribution by the Association.

Mr. McLean advised receiving the resolutions and placing them on file, and doing our best individually to contribute to this fund.

MR. FULLER spoke in favor of his motion, and stated that he believed a reasonable contribution would be better than individual subscriptions.

MR. MACKSEY. Mr. President, if I may be allowed by the maker of the motion, I would like to substitute therefor a motion to this effect:

"The New England Water Works Association approves the effort that is being made by the Roosevelt Memorial Associa-

tion, and is in full sympathy with it, and heartily recommends to its membership, one and all, to contribute to the success thereof, as far as their means will allow."

(The substitute motion was seconded.).

Mr. McLean. I should like to make a motion that the communication be received and laid on the table. I will give you my reasons for it. Only a few days ago this matter was introduced in a similar organization to which I belong, and the question came up some time after its adoption as to whether or not we had the right to take from our treasury twenty-five dollars for this, twenty-five dollars for that, and twenty-five dollars for something else, and we finally had quite a debate and discussion. We better take those things into consideration in advance.

(The motion was seconded.)

Mr. Francis H. Luce stated that he believed the resolutions were taken in the wrong light by the Association, and that no contribution was expected, but merely the moral support of the Association of the Memorial Committee and its work as outlined.

Mr. Carmody believed that the Association was on dangerous ground in doing more than receiving the communication and placing it on file. He spoke of the possible political influence, and compared the action of other organizations that simply received and placed on file the resolutions.

Mr. Richard W. Sherman. In view of all that has been said, I move that the communication be received, placed on file, and laid on the table, that we acknowledge receipt of the communication and by laying it on the table it can be taken up at any time for such disposition as the Association may see fit. I take it that the members do not care to act hastily, and at the present time we do not seem to have time for any prolonged discussion. If it is laid on the table we can take it up at any time.

Mr. McLean. I accept that amendment.

President Killam. I understand you make that amendment to the original motion?

Mr. Sherman. I do.

Mr. McLean. I made a subsequent amendment, which I think was seconded, and I understood it was before the body for debate and action.

Mr. Luce spoke in favor of action for or against endorsement and opposed laying the communication on the table.

(The question came upon the motion that the communication be received and laid upon the table, which was carried.)

President Killam. Is there anything further to bring before the Association before we start on the reports of committees?

Mr. R. J. Thomas. Mr. President, I move that the Chair be authorized to appoint a nominating committee of five members to bring in a list of candidates for the officers of the Association for the coming year.

(The motion was seconded and carried.)

President Killam. Is there anything further before we start on the committee reports?

In Re Department of Public Works.

Mr. H. V. Macksey. I am not sure whether this is the proper time to bring before the Association a matter which came before the Executive Committee and was referred to me by that committee, but possibly it will be just as well to get it out of the way now.

I would say that one of the reasons I am opposed to the Association as an association endorsing good movements in such a way that we might be expected later on to back up our endorsement, is that this one comes before us in that way.

This Association showed its approval and endorsement of a bill introduced in the Senate of the United States to create a Department of Public Works. It is a long bill, about four or five pages, so that I will not attempt to read it to you now, but will simply say to you that the idea is this: that at the present time the public works of the United States are managed piecemeal by various departments, and a very large proportion of the engineering works of the country, which are built mainly to assist in the peaceable pursuits of the people, are in charge of the Army and Navy. It has been felt by the civil engineers of the country, architects, builders, workers, and others, that that was an improper method of managing our affairs. And a bill has been introduced, that a Department of Public Works be established,

which will take care of the planning and designing of all our civil public works, leaving to the Army and Navy only the military affairs. This Association has been asked to endorse that.

The letter which came to our President from Mr. Langdon Pearse, sanitary engineer of the Sanitary District of Chicago, who is one of the officers of the Engineers', Architects', and Contractors' Conference on National Public Works, which is promoting this scheme, says:

"I am sending you enclosed a report giving the proceedings of the Chicago meeting of the Engineering Council. I trust that this will give you the information to present to your society, so that some action can be taken thereon regarding the support of the bill now before Congress.

"I would suggest that an appropriate motion be made to be sent to Senators and Congressmen of Massachusetts, as well as the other New England states, urging them to support the bill, if that is the sense of the convention.

"I also understand that Mr. Leighton, who is handling the executive work of the conference, is now asking for contributions, but I understand that this will be through the national societies. If you anticipate active support, it might be well if you would write to Mr. M. O. Leighton and get further details, in case you have not already received them."

Now, the idea is simply this, — that they wish the endorsement of this Association as to the general movement, and whether the members of this society are sufficiently posted to be willing to give that endorsement or not I do not know. But if we do give that endorsement, we should give it simply as an endorsement, and not bind this society, directly or by implication, to provide funds to carry it through. It is simply an engineer's problem, and this society, although it is composed largely of civil engineeers, is not a society of engineers. This would be a benefit, of course, to many men who are in public works designing and constructing, who are not engineers, but if they wish to help it they could help it individually, both by their efforts and financially. The principal object is "to educate the people concerning the need of consolidating the vast public enterprises of the nation under one single department, which would be known as The Department of Public Works."

And, therefore, Mr. Chairman, I move that the Chair appoint a committee of three to consider this matter and advise the society of the action it should take in the matter, if any.

(The motion was seconded and carried.)

PRESIDENT KILLAM. I will appoint the committee later. The Secretary has a communication from the "National Drainage Congress," which he will read.

The Secretary read communication from National Drainage Congress as follows:

CHICAGO, ILL., September 24, 1919.

MR. WILLARD KENT, *Secy.*,
NEW ENGLAND WATER WORKS ASSN.,
NARRAGANSETT PIER, R. I.

My dear Sir, — Permit me to advise you that the National Drainage Congress will have its eighth annual meeting at the Planters' Hotel, St. Louis, Mo., November 11, 12 and 13, 1919, and to ask that you give this meeting such publicity among your members as you can, and extend to them an invitation to attend this congress and take part in its deliberations.

We believe the matter is of interest to you and your members, as the National Drainage Congress is concerned with the development of the natural resources of our country and the protection of the public health by preventing and remedying such unfortunate conditions as may be caused by the existence of swamp lands and as may follow the floods of our rivers.

We believe that these matters are of sufficient importance to interest all American citizens, and earnestly request your aid in the matter of publicity and attendance at this Eighth Annual Meeting.

Thanking you for your courtesy, I am

Very truly yours,
NATIONAL DRAINAGE CONGRESS.
By JOHN A. FOX, *Director.*

On motion of Mr. Hugh McLean, duly seconded, the communication was received and placed on file.

REPORTS OF COMMITTEES.

Collection and Standardization of Rainfall and Run-off Measurements.

(William T. Barnes, Chairman.)

The Committee to Consider Collection and Standardization of Rainfall and Run-off Measurements submitted its report, as follows:

BOSTON, MASS., September 22, 1919.

NEW ENGLAND WATER WORKS ASSOCIATION,
715 TREMONT TEMPLE,
BOSTON, MASS.

Gentlemen, — Your committee appointed to "Consider Collection and Standardization of Rainfall and Run-off Measurements, particularly in New England," beg to report:

Three meetings have been held, — one jointly with the Boston Society of Civil Engineers' Committee on Run-off.

As a result of the joint conference, your committee conclude that it should confine its work to watersheds, the yield from which would be of interest from the water-works standpoint, leaving data bearing more particularly upon water-power developments for the consideration of and publication by the committee appointed by the Boston Society of Civil Engineers.

Accordingly your committee has taken steps to —

1. Collect, with the intent to publish, rainfall and run-off data which have been reported by various water-works operators but not hitherto published in form accessible to the membership of this Association;
2. Stimulate operators having facilities for obtaining such records but who have not heretofore done so, to begin recording the available data in form suitable for its publication;
3. Publish references to such data as are regularly published in reports readily accessible to the membership and thus avoid duplication of record;
4. Bring down to date the valuable rainfall records presented to this Association in 1913 by Mr. X. H. Goodnough.

With this end in view, your committee has communicated with numerous water-works operators, requesting that they compile these data in form similar to that recorded in the report of Committee on "Yields of Drainage Areas" as recorded in Vol. XXVIII, pages 397–555, 1914, and send to your committee for publication in the JOURNAL.

It is, therefore, to be hoped that in some future issues of the JOURNAL the following data will be published:

1. Rainfall data, 1914–1918, inclusive, for all of the recording stations included in the able paper presented by Mr. X. H. Goodnough in December, 1913, thus making available long-time records of rainfall from stations well scattered over New England and eastern New York, with records brought down nearly to date.
2. Run-off data on streams utilized primarily for water-works purposes, —
   (*a*) Data covering from 1912–1918 in continuation of the data so well presented by the 1912 Committee on "Yield of Drainage Areas";
   (*b*) Similar data not heretofore published, to be arranged in form substantially the same as in the report of the earlier committee.

Your committee would urge all members who may have records of flow of streams to submit their data to your committee, setting it up, if possible, substantially in the same form as was used by the 1912 Committee and recorded in Vol. XXVIII, page 397.

To those who have never recorded the run-off and rainfall in systematic form, we would urge the beginning of such records, that the records may be made available by publishing in the JOURNAL from time to time.

We would also urge the judicious placing of additional rain gages on watersheds under the care of local observers, postal-card reports being sent to the superintendent monthly.

Respectfully submitted,

WILLIAM T. BARNES.

On motion, duly seconded, it was voted that the report be received and the committee continued.

A National Water Law.

(Caleb M. Saville, Chairman.)

The Committee on a National Water Law submitted its report through Mr. Caleb M. Saville, chairman, as follows:

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Your Committee on a National Water Law respectfully submits the following report of progress:

On account of war activities, it has been impracticable for the members of the committee to meet and discuss this matter as frequently as desirable, or to attend meetings of other bodies considering the same subject.

Individual members, however, have interested themselves so far as possible and to some considerable extent. It is now possible for the matter to be taken up and given the attention which it deserves.

We are impressed with the difficulties which beset a local society in gathering data concerning a national question. We are advised that the Water Conservation Committee of the Engineering Council also has this matter under consideration. Realizing that that body, through its extended membership and affiliated associations, is probably the best equipped to make substantial progress, and also realizing that much more can be accomplished by concentration of effort through one representative body, we respectfully recommend that your committee be continued and further authorized to take up the matter with the Water Conservation Committee of the Engineering Council and report progress from time to time to this Association.

Respectfully submitted,

CALEB M. SAVILLE, *Chairman of Committee.*

OCTOBER 1, 1919.

On motion, duly seconded, it was voted that the report be received, the recommendations adopted, and the committee continued.

Report on Power Test Codes of the American Society of Mechanical Engineers.

(Caleb M. Saville, Chairman.)

The committee to represent the New England Water Works Association at the public hearings of the American Society of Mechanical Engineers for the discussion of Power Test Codes of that society, reported as follows:

To the New England Water Works Association:

At the invitation of the American Society of Mechanical Engineers, the New England Water Works Association designated the writer to represent the Association at the meetings of the committee appointed to revise the power test codes of the American Society of Mechanical Engineers.

Several meetings have been held, and substantial progress has been made. This matter is now well in the hands of a very competent committee of twenty-eight, of which Mr. Frederick R. Low is chairman. This committee has on it representatives from various technical societies particularly interested in power development and transmission, and its work is now carried on with vigor.

Attached to and made a part of this report is a bulletin* giving the personnel of the individual committees and the prospectus of the work. Request has been made of the chairman that these bulletins be sent hereafter to the Secretary of the New England Water Works Association so that this Association may be informed of the doings of the committee.

Respectfully submitted,

Caleb M. Saville.

October 1, 1919.

On motion, duly seconded, it was voted to accept the report.

Uniform Accounting.

(Albert L. Sawyer, Chairman.)

Haverhill, Mass., September 27, 1919.

To the New England Water Works Association:

Gentlemen, — In behalf of the Committee on Uniform Accounting I beg leave to submit the following:

This committee has been unable to get together since last January, and therefore has made no progress on the subject assigned it since that time. I would recommend that the committee be re-arranged either with all new members or with a new chairman.

One thing that has handicapped us is the fact that the members are not near

* Filed at office of N. E. W. W. Assn.

enough together to arrange meetings, and we have not seemed to be all together at any of the monthly meetings.

Both Mr. MacKenzie and Mr. Hathaway have, I think, considerable data on the subject.

Personally, I do not seem to have the time necessary to put into this work and should appreciate it if I might be relieved of membership, or at least, if the committee be retained, that another member be made chairman.

It is now three years since the committee was originally appointed, and as so little has been done, I think that if the convention thinks that the subject is of sufficient importance to go on with, they will decide that a new committee might expedite matters, and if not a new committee at least a shake-up in the present arrangement.

Regretting that I have nothing better to offer,

Very respectfully,

ALBERT L. SAWYER, *Chairman*.

Committee:

ALBETT L. SAWYER.
SAMUEL H. MACKENZIE.
ALFRED R. HATHAWAY.
EDWIN L. PRIDE.

On motion of Mr. R. J. Thomas, duly seconded, it was voted that the communication be received and the committee continued.

MR. HUGH MCLEAN. Mr. President, I would like to ask the gentleman who made that motion what his reason is for continuing the committee. Now is the time to change those things. If a man has resigned, what is the object in not letting him resign? Do you know of any information that has not been imparted to this body, so that we can vote intelligently? I do not know how to vote on it.

MR. R. J. THOMAS. My reason for making the motion that the committee be continued is that I know that these men are well qualified for this work. We all know that it has been difficult to get men together during the last two or three years. I think Mr. Sawyer and Mr. Hathaway, and the other members of the committee, are very well versed in that matter, and ought to be given another opportunity. The work of the committees for the last year or two has been greatly hampered, and I think if we continue this committee a little longer we can get results. That was the only object I had in making that motion.

PRESIDENT KILLAM. Perhaps it would be well for the President to make a statement right here. I think one of the hardest things

that the President has to do is the appointing of committees. If you appoint men in a certain section where they can get together at committee meetings, sometimes it looks as though it was a clique; if you appoint them from various districts, it is impossible many times for them to get together and report. Now, the President this year, during the last three or four months, since we got down to a working basis, has attempted to prod all these committees. And perhaps that is the reason why some of them are asking to be relieved.

Personally, I know that this committee has invaluable information, if they will only get together and compile it, but the local conditions have been such that they have not been able to give their time to it. I appreciate it very much. But still we would like to clear up the calendar, and I am in hopes that the calendar will be cleared up before the end of this year on these special committees.

And so, no matter who is your President, do not criticize the committee appointments, until you know his reasons for making them. Sometimes it is advisable to appoint a local committee where they can get together and clear up a subject promptly; at other times it is advisable to appoint a committee, the same as this one, from various sections, who have the information and who in time will give it to us, which will be invaluable when it is compiled. I can say that about this committee because I did not appoint it; it was appointed before I assumed the chair.

Standard Specifications for Water Meters.

(Charles W. Sherman, Chairman.)

Progress report of the Committee on Standard Specifications for Water Meters was read by Charles W. Sherman, chairman, as follows:

To the New England Water Works Association:

During the disturbed conditions resulting from the war, it has not seemed wise for your committee to take any steps in the direction of preparing standard specifications for water meters. Since the conclusion of the war some preliminary work has been done.

The committee has not held a meeting, but some correspondence has been carried on and one of the members of the committee has had conferences with

a representative of the meter manufacturers. We are advised that the manufacturers have been discussing the question of standards and that some progress has been made in this direction. It is probable that within a short time sufficient progress will have been accomplished so that it may be desirable for the manufacturers and your committee to discuss the matter in joint session, after which it will probably be possible to prepare at least a preliminary draft of a meter specification which can be submitted to the Association for discussion.

The committee, therefore, reports progress and hopes to be able to submit a second progress report containing matter for discussion at the next annual meeting of the Association.

Respectfully submitted for the committee,

CHARLES W. SHERMAN, *Chairman.*

SEPTEMBER 30, 1919.

On motion, duly seconded, it was voted that the progress report of the committee be received and the committee continued.

President Killam stated that the Committee on Leakage of Pipe Joints hoped to be able to make a report before the close of the convention.

Adjourned.

AFTERNOON SESSION.

President Killam in the chair.

Mr. Theodore Horton, chief engineer, New York State Department of Health, read a paper entitled, "The Supervision of Public Water Supplies by the New York State Department of Health."

The paper was discussed by Messrs. William P. Mason, Frank L. Fuller, R. W. Sherman, L. M. Hastings, Frank A. Barbour, Caleb M. Saville, F. W. Green, Dow R. Gwinn, and Bertram Brewer.

Dr. William P. Mason, professor of chemistry, Rensselaer Polytechnic Institute, Troy, N. Y., gave a talk on "Swimming Pool Management."

The subject was discussed by Mr. Arthur L. Crane.

Adjourned.

EVENING SESSION.

President Killam presiding.

The Secretary read the names of the following applicants for membership, all of whom had been approved by the Executive Committee, and they were duly elected:

Active: Harry A. Burnham, Newtonville, Mass., fire protection engineer; William B. McCaleb, Philadelphia, Pa., general superintendent, Water Companies, Pennsylvania R. R. — 2.

Associate: Badger Meter Manufacturing Co., Milwaukee, Wis. — 1.

PRESIDENT KILLAM. For the committee on the bill now before the United States Senate, establishing the Department of Public Works, I will appoint Henry V. Macksey, Caleb Mills Saville, and Charles W. Sherman; for the Nominating Committee I will appoint the following past-presidents: Robert J. Thomas, Frank A. McInnes, Robert C. P. Coggeshall, William F. Sullivan, and George W. Batchelder.

Is there anything further to be brought before the Association?

MR. CALEB M. SAVILLE. There is one thing I want to speak of before the business meeting. The President this morning gave what we all thought was a very fine address, which seemed to be well received, and you gave him a vote of thanks, which seemed to me to be rather an empty honor, after all, because you did not do what he asked you to do.

He had several very excellent suggestions in his address, and I think that we would better consider some of them and see if we do not want to do something with them. Two of them, I think, are that a committee of three be appointed to study the finances of the Association and report on a budget system for 1920, on or before the December meeting, and that a committee of three be appointed to make a study of the constitution and by-laws of the Association, to ascertain if there are any changes that it seems desirable to make.

Now, Mr. President, I should like to make a motion that those committees be appointed by the President.

(The motion was seconded and carried.)

Mr. J. Waldo Smith, chief engineer, Board of Water Supply, New York City, read a paper on " Schoharie Development of the New York Water Supply."

Mr. William T. Barnes read a paper entitled, " The Ten-Million-Gallon Covered Reservoir of the Dayton Water Works," prepared by Leonard Metcalf and William T. Barnes, consulting engineers, Boston.

In connection with this subject Mr. Frank L. Fuller, of Wellesley,

Mass., told of the 1 600 000 gal. covered reservoir, flat slab, which was constructed for the town of Webster, Mass., in 1914. Mr. Caleb M. Saville and Mr. Morris Knowles also took part in the discussion.

Adjourned.

WEDNESDAY, OCTOBER 1, 1919.

Under the auspices of the Water Works Manufacturers Association, a steamer was chartered for a day's trip on the Hudson River. The morning and afternoon business sessions were conducted aboard the boat.

MORNING SESSION.

President Killam in the chair.

Mr. Charles W. Sherman, consulting engineer, Boston, read a paper entitled, "Protecting Iron and Steel Standpipes from Corrosion."

The discussion was participated in by Messrs. Frank L. Fuller, Rudolph Hering, Francis T. Kemble, Frank A. Barbour, Lewis M. Bancroft, A. P. Folwell, J. M. Diven, John Cullen, H. T. Gidley, S. E. Killam, E. M. Nichols, J. F. Sullivan, T. R. Kendall, and Frank J. Gifford.

At this point Vice-President H. V. Macksey took the chair.

Mr. Bertram Brewer, assistant engineer, State Department of Health, Boston, read a paper on "Public Control over New Streets, in Relation to Extension of Water Mains."

Messrs. F. J. Gifford, David A. Heffernan, J. M. Diven, T. J. Carmody, W. A. MacKenzie, George A. Stacy, M. N. Baker, Beekman C. Little, Caleb M. Saville, and Francis F. Longley participated in the discussion.

MR. SAVILLE. I should like to make a motion that a committee be designated by the President to consider, collect data, and report with recommendations on the matter of assessments of the cost of main pipe extensions, and the relation of new street layouts in connection therewith, this report to be submitted not later than the next annual convention.

MR. FRANCIS F. LONGLEY. It seems to me that in proposing

a motion of this sort, such as Mr. Saville has proposed, for the consideration of this question, it would be well to include therein a proposal for the consideration also of coöperation that might be secured on the part of real estate men, of the architectural profession, in order to well round out the question.

MR. J. F. SULLIVAN. Inasmuch as this is a very interesting subject and the discussion has not been completed on it, I move that this matter of the resolution be laid on the table until the discussion of Mr. Brewer's paper is completed.

(Mr. Sullivan's motion was duly seconded and carried.)

Adjourned.

AFTERNOON SESSION.

President Killam presiding.

Col. Francis F. Longley, consulting engineer, New York City, gave a talk on " Water Supplies for the American Expeditionary Forces."

In the absence of Mr. Frank A. McInnes, chairman of the Committee on Grading Water Works with Reference to Fire Protection, Mr. Henry V. Macksey, a member of the committee, read a progress report, as follows:

THE COMMITTEE ON GRADING WATER WORKS WITH REFERENCE TO THEIR VALUE FOR FIRE PROTECTION.

A revised standard schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions was issued by the National Board of Fire Underwriters in December, 1916. The changes from the preliminary schedule prepared in 1915 and submitted as an appendix to the report of this committee on September 15, 1916, are comparatively slight; the only important ones with regard to the grading of water works are Sections, 21, 31, and 32.

Section 21, as printed at the top of page 31 in our former report, is now changed to read as follows:

21. Small mains in the distribution system:
    (a) For per cent. of 4-in. or smaller mains supplying hydrants: Use ½ Deficiency Scale.

(*b*) Add 1 point for each mile of 4-in. or smaller pipe. Do not include areas in which block fronts have less than one fifth the lots built upon, or which are separated from the main system by a natural barrier or considerable open space, nor in larger cities areas outside a 5-mile radius of the district considered.

Reduce the points of deficiency 5 per cent. for each 10 lb. average normal static pressure above 20 lb. if the fire department response throughout the city is such that at least one half the companies are engine companies, otherwise for each 10-lb. pressure above 60 lb. Normal static pressure to be assumed as that carried normally at time of fire. Where there are marked differences in pressure due to topography or separate services, both the above may apply, and the average reduction made.

Sections 31 and 32, as printed at bottom of page 34 and at top of page 35 in our former report, are changed to read as follows:

31 and 32. Size and Installation of Hydrants. — Hydrants shall be able to deliver 600 gal. per minute, with a loss of not more than 2½ lb. in the hydrant and a total loss of not more than 5 lb. between the street main and outlet; they shall not have less than two 2½-in. outlets and also a large suction connection where engine service is necessary. They shall be of such design that when the hydrant barrel is broken off the hydrant will remain closed. Street connection shall not be less than 6 in. in diameter and shall be gated. Hose threads on outlets should conform to the National Standard. Flush hydrants, requiring chucks to be screwed on, are considered undesirable, especially in sections of the country subject to heavy snowstorms, because of delay in getting in operation. Cisterns are considered as of improper type.

31. Hydrants too small or of improper type; to include all with 4-in. connection to main, or with small barrel or foot valve, except those hydrants with large suction outlet in cities using engines and with static pressure of at least 60 lb.; also to include all with single 2½-in. outlet, and all flush hydrants requiring chuck to be screwed on or where covers over hydrant barrel or operating nut of controlling gate are liable to be frozen in or covered by heavy snowfall, except that flush hydrants, with an adequate number of chucks provided having more than one 2½-in. outlet, are to be considered on basis of ½ deficient. If in the high value district considered, there are more hydrants than are required for proper spacing, and the small hydrants are not generally used by the fire department, use in determining the deficiency only the number of small hydrants required to make up the total number necessary for proper distribution; i. e., do not charge for the surplus small hydrants.

(*a*) Use $\frac{1}{5}$ Deficiency Scale for those in high value districts.
(*b*) And add $\frac{1}{5}$ Deficiency Scale for those elsewhere.

Reduce points of deficiency for (*b*) 5 per cent. for each 10 per cent. of 4-in. and smaller pipe charged for under Item 21.

In these changes a concession has been made to the opinion of the committee as expressed in their first report. It will be noted that the method of computing deficiencies for 4-in. pipe has been slightly modified; that when such deficiency has once been charged on account of small size of pipe but little additional deficiency is computed on account of small hydrants on this pipe.

It is obviously the intention of the instructions issued for computing deficiencies to penalize the ordinary commercial 4-in. hydrant under all conditions, but your committee is still of the opinion that this hydrant should not suffer under certain conditions such as when located in an outlying isolated section of a community, or in any location where a discharge not exceeding 500 gal. per minute could be reasonably required.

We are satisfied that a hydrant with 4-in. foot valve can be designed, in fact has been designed, to meet the requirements of the Standard Schedule, and we are therefore decidedly of the opinion that a hydrant capable of delivering two fire streams of 250 gal. per minute each with a loss not exceeding 2½ lb. should be recognized in its proper place.

The other principal point raised by the committee was the danger of crippling the system by the breakage of too frequent or unduly large fire pipe connections. Your committee is still of the opinion that such conditions should be penalized.

The committee wishes to present to the underwriters a more complete record of the disastrous effects of such connections than it now has in its possession and would request our members to forward to the committee all records which they may have of damage resulting from waste and excessive use of water through fire pipe connections.

We are advised by Mr. George W. Booth, chief engineer, that the National Board of Underwriters was unable during the war period to give much attention to the application of the schedule on account of being so fully occupied with government fire protection matters, but it has recently taken it up again, and is actively

engaged in applying it throughout the country. It has up to date made final gradings on about 225 cities. The schedule has been adopted for use by the insurance organizations having jurisdiction in the greater part of the country, including the Southeast, the whole of the Middle West, and New England; the New York State Association is now considering its adoption.

With regard to experiences in New England, Mr. John H. Caldwell, engineer of the N. E. Insurance Exchange, writes us as follows:

"Some time during the last year the Exchange adopted this schedule in connection with the adoption of a standard mercantile schedule which is eventually to supplant the various schedules now in use throughout New England.

"Our first work in connection with the Grading Schedule was the tentative application in approximately twenty-eight cities and towns throughout Massachusetts, ranging from the second to tenth classes. On completion of this work, test applications of the Building Schedule were made, all of which was preliminary work in preparation of the final application of the schedule.

"This summer work was finally started in the city of Cambridge on the application of the schedule for final rating, and this work in that locality is now nearing completion but no rates have been published as yet based on the Grading Schedule and the new mercantile schedule.

"In order that you may be familiar with the results obtained by the application of the Grading Schedule, I am giving you the list of cities and towns [page 376] where we have applied same, with the total number of points of deficiency for all items considered in the schedule, the class of the city, and the total points of deficiency under the item of water works, which I think is the one which you are most vitally interested in."

The committee in its first report stated that it was satisfied that the Standard Schedule was a long step in the right direction, but that until results of its application to water-works systems with which the members are familiar have been made known, criticisms of the details of the schedule were not of controlling significance. As stated in Mr. Caldwell's letter, the application has now been made to a sufficient number of New England cities and warrants study of the details. This must obviously be done by men entirely familiar with the systems to which the schedule is applied. It would be extremely helpful to the committee if the superintendents

of the systems which have been graded would examine the details of the grading and report to this committee any criticism or comment which they may have to make upon its application and the fairness of the results.

MASSACHUSETTS.

City or Town.	Water Works Deficiency.	Total Deficiency.	Class.
Attleboro	629	2586	6th
Ayer	1 032	3 535	8th
Belchertown	1 700	4 486	9th
Bridgewater	1 098	3 572	8th
Brookline	341	1 493	3d
Cambridge	505	1 919	4th
Chelsea	141	1 696	4th
Dedham	827	2 833	6th
Gardner	485	2 587	6th
Great Barrington	815	3 018	7th
Haverhill	471	2 084	5th
Holyoke	164	1 248	3d
Housatonic	1 029	3 743	8th
Lawrence	356	1 928	4th
Lowell	178	1 586	4th
Lynn	287	1 528	4th
Melrose	390	2 122	5th
New Bedford	56	1 309	3d
Newburyport	626	3 417	7th
North Adams	436	2 619	6th
Norwood	635	2 718	6th
Pittsfield	308	2 183	5th
Plymouth	662	2 599	6th
Salisbury Beach	1 101	3 586	8th
Somerville	277	1 637	4th
Springfield	95	999	2d
Swampscott	341	2 197	5th
Waltham	451	2 027	5th
Woburn	513	2 289	5th
Worcester	54	1 298	3d

Mr. Booth says, "I think we are safe in saying that the reception of the schedule by the insurance organizations and city officials generally has been very satisfactory and that it has brought about a better understanding of the various fire protection features involved than has been possible heretofore."

While some water-works managers may feel that deficiencies charged against their departments are great, the low rating given may be used to advantage when appealing for appropriations to extend or improve the system under their charge.

For the committee,

FRANK A. McINNES,
Chairman.

MR. MACKSEY. Now, gentlemen, the only comment I personally have to make upon that is the fact that the representative of the underwriters, Mr. Booth, thinks that we, in the cities, are all very well satisfied. Perhaps when you read over the classification you are given you may feel satisfied. In the city of Woburn I feel sure the people will not feel satisfied, because they have been led to believe that they were in Class 3, and by doing certain things would come into Class 2, and here we find we are in Class 5. And we intend to get a copy of our grading and go through it point by point and see what we can do to improve our conditions and to claim what we believe to be fair treatment from the underwriters.

Now, of course you all understand that the underwriter's idea is perfection at other people's expense — particularly at other people's expense. No matter what we do, they will ask for something better. That is not such an awful thing after all, because it will keep us trying to do better; we shall never be perfect but we will keep doing better.

In regard to the 4-in. fire hydrant, I think I speak for a number of men who deal with small cities and towns and where it would be foolish to spend our money on hydrants with 5- or 6-in. valves, when we could have a greater number of hydrants with 4-in. valves more advantageously placed and where they could do greater service for our cities and towns. We intend to stick to and defend the 4-in. hydrant until they show us that that is not so. [*Applause.*]

On motion, duly seconded, it was voted that the report of progress be accepted and the committee continued.

Adjourned.

Evening Session.

President Killam in the chair.

The Secretary read the following list of applicants for membership, approved by the Executive Committee, and they were duly elected:

Active: James Bedell. Ossining, N. Y.; Floyd A. Nagler, Albany, N. Y., hydraulic engineer.

Mr. H. S. R. McCurdy, engineer Miami Conservancy District, Englewood, Ohio, read a paper entitled, "Hydraulic Fill Dams of the Miami Conservancy District."

Mr. Frank L. Fuller, Mr. Robert E. Horton, Mr. Stephen H. Taylor, Mr. Morris Knowles, and Mr. G. Edward Gilson took part in the discussion.

Mr. Norman J. Howard, bacteriologist in charge, Toronto Filtration Plant, Toronto, Ont., read a paper on "The Operation of and Purification Effected by the New Drifting Sand Filter System at Toronto."

Messrs. Howard W. Green, G. A. Sampson, James M. Caird, Theodore Horton, M. N. Baker, W. C. Hawley, William J. Orchard, Paul Lanham, Morris Knowles, F. F. Longley, and Charles W. Sherman took part in the discussion.

Adjourned.

Morning Session, Thursday, October 2, 1919.

President Killam presiding.

This session was made a superintendents' experience meeting, and was opened by Mr. David A. Heffernan, superintendent Water Works, Milton, Mass., who chose as his subject, "Damages to Hydrants by Motor Vehicles, Their Repairs and Preventives."

The matter of trouble with paint coming off the inside of pipe and the re-painting of the pipe was also discussed, as well as the relative merits of various pipe linings.

The discussion on these subjects was participated in by Messrs. S. H. MacKenzie, Frank J. Gifford, H. T. Gidley, George A. King, W. A. MacKenzie, Francis H. Luce, Dow R. Gwinn, Frank L. Fuller, Stephen H. Taylor, John Cullen, Charles W. Sherman,

Samuel E. Killam, William R. Conard, W. C. Hawley, Edward D. Eldredge, and George A. Benjamin.

The motion of Mr. Caleb M. Saville, which was laid on the table at the morning session of October 1, 1919, that a committee be appointed by the President to consider, collect data, and report with recommendations on the matter of assessment of the cost of main pipe extensions and the relation of new street layout in connection therewith, this report to be submitted not later than the next annual convention, was taken from the table, and after discussion the motion was carried.

Adjourned.

Afternoon Session.

Under the auspices and through the courtesy of the Rensselaer Polytechnic Institute at Troy, N. Y., a visit was made to their new swimming pool, and luncheon was served at the Institute. After the luncheon President Killam introduced Hon. Cornelius F. Burns, mayor of Troy, who spoke as follows:

Ladies and Gentlemen, — I did not know that I was to be called upon, but it makes no difference to Trojans when they are called upon, as they are always ready to perform the duty that is assigned to them.

It is always a pleasure to have people come into our municipality. Our only regret is that the elements are such that we are unable to carry out the program which we had outlined for the day. This is our day for the inspection of our municipal departments, and I had arranged to have a band here and take you down two blocks and have you look over one of the greatest departments in the state of New York — that is, we always make that claim, and we think we are justified in it. However, we can't do it, and I expect it is due in great measure because you people are in the water-works business, and therefore I presume God is with you and He is sending the rain so that when you go back home there won't be any question about having the reservoirs full. And that is the only way you will get full under the present laws of the country. [*Laughter.*]

However, I can assure you it is my great pleasure to be with you

to-day in this short space of time and extend to you a cordial and hearty greeting on behalf of the people of Troy, and we only hope that it will be but a short time when we may be honored by having you with us again, but I assure you that I will not be in office when you come. However, I will be here just the same. I thank you very much. [*Applause.*]

President Killam. I thank you, Mr. Mayor. We greatly appreciate all that has been done for us here in Troy. Only a day or two ago Dr. Mason said that we should have come to Troy instead of Albany for our headquarters. Perhaps Dr. Mason knew better than we did, but he should have advised us earlier in the year.

We are very grateful to Dr. Mason for all that he has done for us. To Mr. Caldwell, who is also chairman of the Manufacturers Committee of Arrangements, vice-president of the R. P. I., and president of no end of concerns in Troy and other places, we extend our heartfelt thanks for all that he has done for us to make our visit to Albany and Troy one round of pleasure.

To Dr. Ricketts, who has been called away to the city, I would say that everything I have ever seen about this institution, from the time we entered the gates until we sat down to what they call a luncheon, has been efficiency, — efficiency first, last, and always; and if this is a luncheon I should like a real good dinner here sometime. [*Applause.*]

I understand that the autos are nearly ready and I will call upon Mr. Patrick Gear to lead us in three cheers.

(Under the leadership of Mr. Gear three rousing cheers were given for the mayor of Troy, three cheers for the City of Troy, and three for Mr. Caldwell.)

After the luncheon, through the courtesy of the Water Department of the city of Troy, a motor trip was made over the Troy watershed. The return to Troy was by way of the State Barge Canal, at which time operation of the locks was demonstrated for the benefit of the members of the Association.

Morning Session, Friday, October 3, 1919.

President Killam in the chair.

The Secretary read the following list of applicants for membership, approved by the Executive Committee, and they were duly elected:

Thomas E. Lawler, Poughkeepsie, N. Y., consulting engineer; B. E. Fox, West Springfield, Mass., clerk water department; J. Frank Whiting, West Springfield, Mass., superintendent water department. — 3.

Mr. Paul Lanham, engineer in charge of waste detection, Washington, D. C., read a paper on " Detection of Losses from Underground Piping Systems."

The discussion was participated in by Messrs. Frank L. Fuller, Dow R. Gwinn, George H. Abbott, S. H. MacKenzie, W. C. Hawley, E. G. Reynolds, A. P. Folwell, and D. A. Heffernan.

Mr. Robert E. Horton, consulting engineer, Voorheesville, N. Y., read a paper entitled, " Watershed Leakage."

Messrs. W. A. MacKenzie, L. M. Hastings, Lincoln Van Gilder, and Charles W. Sherman took part in the discussion.

President Killam. I will take this opportunity to appoint the following committees: Constitution and By-Laws, H. V. Macksey, F. J. Gifford, and R. J. Newsom; Budget, George A. Carpenter, Frank A. Marston, and Edwin L. Pride; Extension of Mains, Caleb M. Saville, W. C. Hawley, and Bertram Brewer.

Adjourned.

Afternoon Session.

President Killam presiding.

The President read the applications for membership, approved by the Executive Committee, of the following persons, and they were duly elected.

Arthur T. Clark, Herkimer, N. Y., superintendent and engineer Municipal Commission; Paul Lanham, Washington, D. C., waste prevention engineer.

Mr. Frederic E. Beck, chief engineer, Consolidated Water Company, Utica, N. Y., read a paper on " Experience in Metering Fire Services."

Messrs. Frank L. Fuller, J. M. Diven, G. H. Abbott, Robert E. Horton, Dow R. Gwinn, Paul Lanham, Lincoln Van Gilder, Charles W. Sherman, W. C. Hawley, Harry H. Burnham, Samuel E. Killam, H. T. Gidley, William F. Sullivan, A. E. Martin, and Edward D. Eldredge took part in the discussion.

A paper entitled, "Dangerous Reduction to Insulation Resistance in High-Pressure Fire-Service Motors Due to Moisture," by William W. Brush, deputy chief engineer, Department of Water Supply, Gas, and Electricity, New York City, was read, in the absence of Mr. Brush, by Mr. Charles W. Sherman.

It was suggested by Mr. Harry Gardner (editor *Engineering World*) that a paper on this subject was read at the last convention of the American Institute of Electrical Engineers — not particularly relating to motors on pumps but motors in general, and suggesting methods for overcoming the difficulty.

Invitation for 1920 Convention.

President Killam. I have here two telegrams sent from Springfield in regard to the next annual convention. The first one reads as follows:

In behalf of the citizens of Springfield, wish to extend cordial invitation to hold next meeting in our city.

Arthur A. Adams, *Mayor.*

The second one reads:

We want you in 1920. Let us welcome you to our city.

Wm. H. Shuart,
President Chamber of Commerce.

These will naturally be referred to the next Executive Committee.

Adjourned.

Evening Session.

President Killam in the chair.

The Secretary read the application for membership, approved by the Executive Committee, of Stephen Bond Story, civil engineer, Rochester, N. Y.

On motion of Mr. Charles W. Sherman, the Secretary was instructed to cast the ballot of the Association in favor of the applicant named, and he having done so the applicant was declared a duly elected member of the Association.

PRESIDENT KILLAM. Is there anything further to come before the Association?

MR. CHARLES W. SHERMAN. I wish we had one of our real orators of the Association here, to say the words that ought to be said in recognition of the many courtesies which have been extended to this Association during this convention. I can't remember when a convention has seemed to be more enjoyable. Although I have not attended all of them, I have attended the greater part of them for the last twenty-five years. This has not been the largest convention we have ever had; I do not know that it has been the best, but it has been one of the best, and certainly it has been extremely enjoyable from every point of view.

We have been indebted to a great many persons, organizations, corporations, and I don't know what else for courtesies of all kinds, and they have helped to make our stay pleasant and enjoyable. We owe them a great deal more than our thanks, but all we can really give them is our thanks, which I am sure we do most heartily.

In order that it may be on our records, I formally move that the thanks of the New England Water Works Association be extended to the City of Albany, the City of Troy, the Rensselaer Polytechnic Institute, the Chambers of Commerce of Albany and Troy, the Water Works Manufacturers Association, the Municipal Gas Company and the Ten Eyck Hotel, for all they have done to make the convention now closing so successful and enjoyable.

I hope I have not omitted in this list any one of the larger organizations. There are, of course, many individuals whom it is impracticable to attempt to mention by name.

(The motion was seconded and unanimously adopted by a rising vote.)

Mr. D. A. Decrow, manager Water Works Department, Worthington Pump and Machinery Corporation, New York City, read a paper entitled, "Tests of the Unaflow Pumping Engine."

Messrs. Harry Gardner, A. P. Folwell, William F. Sullivan, Edward D. Eldredge, and Charles W. Sherman took part in the discussion.

Mr. W. P. Mosteller, U. S. Iron Pipe and Foundry Company, Philadelphia, Pa., gave a talk on the "Test of Bell and Spigot Joint for Gas Pipe at Twenty-five Pounds Pressure."

The discussion was participated in by Messrs. Edward D. Eldredge, Charles W. Sherman, Harry Gardner, Samuel E. Killam, R. L. Hall, William F. Sullivan, and George H. Abbott.

PRESIDENT KILLAM. Is there anything further to be brought before the Association? [*No response.*]

We are now closing what seems to me to be a very interesting and instructive convention, — one, I think, which we have all enjoyed, both from a business point of view and through the entertainments which have been furnished us. We have endeavored to work while we worked and play while we played. And, as far as I know, every one has enjoyed himself, with one exception. That was on the first day, when we gave out the medal. That medal entirely disappeared during the session from the floor of the convention. I am pleased to say to-night that I have the medal in my pocket. [*Applause.*] How I got that medal I am not at liberty to say, because I have no proof where it went to; all I can do is to turn it over to the man to whom it belongs. It has worried me considerably to think that anything like that could happen in a convention of the New England Water Works Association, and I trust it never will happen again.

A motion to adjourn is in order.

MR. CHARLES W. SHERMAN. I move the convention now adjourn.

(The motion was duly seconded and carried.)

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at Pemberton, Mass., Wednesday, June 25, 1919.

Present: President Samuel E. Killam, Henry V. Macksey, Frank A. Barbour, James H. Mendell, Frank J. Gifford, Henry A. Symonds, and Willard Kent.

Nine applications for membership were received and by unanimous vote recommended therefor, viz.: Bernhard Hoffman, Stockbridge Water Company, Stockbridge, Mass.; J. M. Jones, superintendent Bristol and Warren Water Works, Bristol, Conn.; A. Maxwell McKenzie, assistant engineer Water Works, Wallingford, Conn.; Ernest L. H. Meyer, superintendent Water Department and city engineer, Glens Falls, N. Y.; Charles B. Hayward, president Fire and Water Engineering, Inc., New York, N. Y.; William J. Orchard, civil engineer, New York, N. Y.; Theodore Reed Kendall, engineering editor *The American City*, New York, N. Y.; John H. Lance, consulting engineer, Wilkes-Barre, Pa.; Kenneth Q. Volk, civil engineer, Los Angeles, Cal.

Voted: That a meeting of the Executive Committee be held at the call of the President to confer with a committee of the Manufacturers Association in regard to constructive program of entertainments for the next annual convention.

Adjourned.

Attest,

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Friday, August 1, 1919, pursuant to call issued by the President.

Present: President Samuel E. Killam and members Charles

W. Sherman, Percy R. Sanders, Frank A. Barbour, Patrick Gear, Lewis M. Bancroft, Willard Kent, and, by invitation, Frank A. McInnes and T. C. Clifford, Burt B. Hodgman and John A. Kienle of the Water Works Manufacturers Association.

After discussion, on motion of Mr. Barbour, seconded by Mr. Gear, it was voted: That pending approval of this policy for future conventions by the Association as a whole, the exhibit and entertainment features at the Albany convention be delegated to the Manufacturers Association, it being understood that no manufacturer not a member of the New England Water Works Association shall be permitted to exhibit, that a New England section of the Manufacturers Association shall be formed, and that associate members of the New England Water Works Association shall be invited to join this local section, or — if exhibitors without membership — shall pay a reasonable charge for the privilege of exhibiting, and that badges of active members and of guests of active members shall be paid for by the New England Water Works Association and distributed by the Secretary of the Association.

Adjourned.

Attest,

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., on Wednesday, September 17, at 2 o'clock P.M.

Present: President Samuel E. Killam and members James H. Mendell, Frank J. Gifford, Patrick Gear, Lewis M. Bancroft, and Willard Kent.

Four applications for membership were presented, viz., Charles R. Barker, N. E. Insurance Exchange, 141 Milk Street, Boston, Mass.; John S. Caldwell, N. E. Insurance Exchange, 141 Milk Street, Boston, Mass.; John A. McKone, president, Board of Water Commissioners, Hartford, Conn.; and Samuel A. Sewell, superintendent, St. John Water and Sewerage Department, St. John, N. B.; and the applicants were by unanimous vote recommended therefor.

The report of "Committee on Award of the Dexter Brackett Memorial Medal," — Messrs. William T. Barnes, William F. Sullivan, and George W. Batchelder,— recommending the award for the year 1918 to Mr. David A. Heffernan, superintendent Milton Water Works, Milton, Mass., for his paper entitled, "Practical Methods for Detecting Leaks in Underground Pipes," was received, and it was unanimously voted: That the award of the Dexter Brackett Memorial Medal for the year 1918 be, and hereby is, made to Mr. David A. Heffernan.

The President announced the death of Mr. John Mayo, superintendent of the Bridgewater Water Works, a member of this Association, and on motion of Mr. Gifford seconded by Mr. Bancroft, Messrs. Horace Kingman, Alvin C. Howes, and D. N. Tower were appointed a committee to prepare a memoir.

A communication from the Roosevelt Memorial Association asking for endorsement and assistance in their work was referred to the Convention of the Association for action.

The President appointed as a committee on accommodations for the winter meetings of the Association, Messrs. Frank J. Gifford, Charles W. Sherman, and Frank A. Barbour.

Adjourned.

Attest,

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at the Ten Eyck Hotel, Albany, N. Y., September 30, 1919.

Present: President Samuel E. Killam, Henry V. Macksey, Charles W. Sherman, Patrick Gear, Lewis M. Bancroft, and Willard Kent.

Twenty applications for active membership and two for Associate membership were received and recommended therefor, viz.:

Members: Charles R. Barker, engineer Municipal Protection Dept., N. E. Insurance Exchange, Boston, Mass.; James Bedell, Municipal Bldg., Ossining, N. Y.; H. A. Burnham, Newtonville, Mass.; John S. Caldwell, engineer, N. E. Insurance Exchange, Bos-

ton, Mass.; Arthur T. Clark, superintendent and engineer, Municipal Commissioners, Herkimer, N. Y.; Francis W. Collins, consulting engineer, New York, N. Y.; B. E. Fox, clerk Water Dept., West Springfield, Mass.; Irving H. Henderson, foreman, Cambridge Meter Dept., Cambridge, Mass.; John F. Laboon, of Chester & Fleming, consulting engineers, Pittsburgh, Pa.; Paul Lanham, water survey engineer, Bryant Street Pumping Station, Washington, D. C.; Thomas F. Lawlor, president, Board of Public Works, Poughkeepsie, N. Y.; Francis C. Millspaugh, hydraulic engineer, Lowell, Mass.; William B. McCaleb, general superintendent, Water Companies, Philadelphia, Pa.; John A. McKone, president, Board of Water Commissioners, Hartford, Conn.; Floyd A. Nagler, civil engineer, Albany, N. Y.; Eliot B. Norton, superintendent, Cambridge Water Works Co., Cambridge, N. Y.; Francis J. Seery, professor hydraulic engineering, Cornell University, Ithaca, N. Y.; Samuel A. Sewell, superintendent St. John Water and Sewerage Dept., St. John, N. B.; Stephen B. Story, civil engineer, Rochester, N. Y.; J. Frank Whitney, superintendent Water Dept., West Springfield, Mass.

Associates: Badger Meter Mfg. Co., Milwaukee, Wis.; Flower Valve Mfg. Co., Detroit, Mich.

Three applications for reinstatement were received, and it was unanimously voted that the applicants be and hereby are reinstated to associate membership on complying with the requirements of the Constitution.

Attest,

WILLARD KENT, *Secretary.*

Volume 33.
Number 4.
Section 1.

DECEMBER, 1919.

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OF THE

New England Water Works Association.

1919.

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EDWIN L. PRIDE, Public Accountant, Boston, Mass.
FRANK A. MARSTON, Designing Engineer, Metcalf & Eddy, Boston, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXXIII. December, 1919. No. 4, Section 1.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE HYDRAULIC FILL DAMS OF THE MIAMI CONSERVANCY DISTRICT.

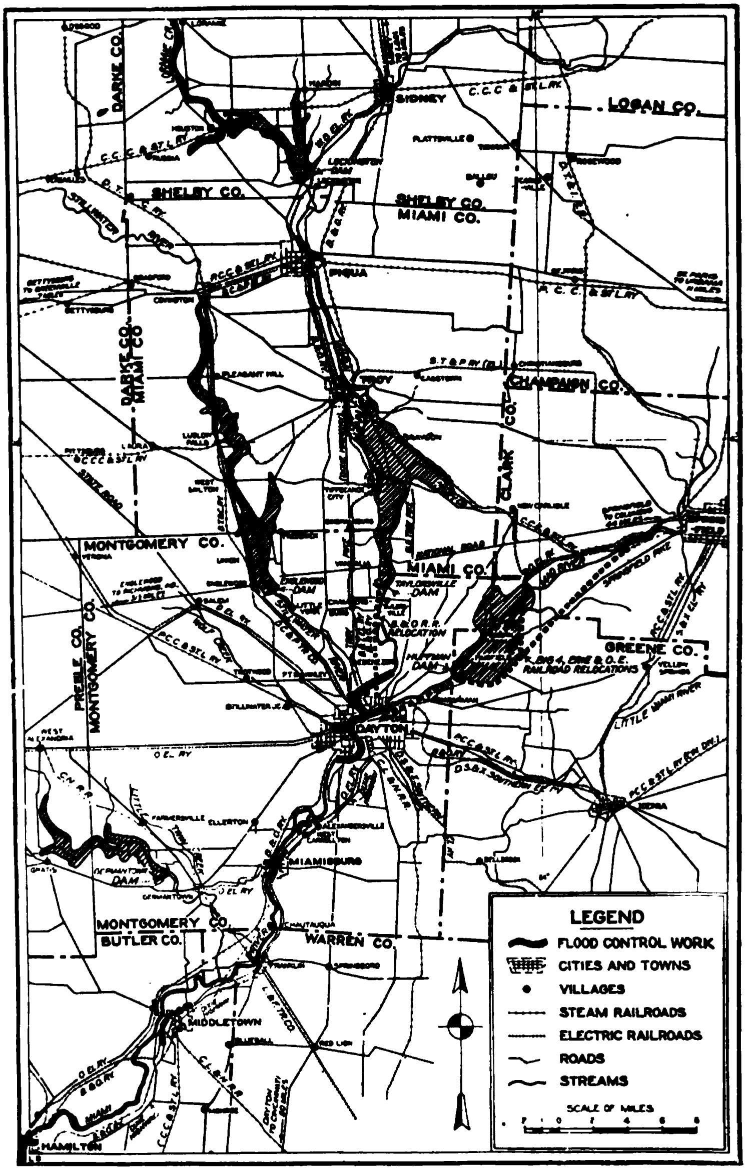
BY H. S. R. MC CURDY, DIVISION ENGINEER, MIAMI CONSERVANCY DISTRICT.

[*Read September Convention, 1919.*]

PRELIMINARY.

The Miami Valley. The Miami River flows through the southwestern part of the state of Ohio, forming, at its junction with the Ohio River, the southwest corner of the state. With its tributaries it drains 5 430 square miles in southwestern Ohio and southeastern Indiana. The general width of the valley is from a quarter of a mile to three miles, and its length is about 120 miles. Geologically it is located near the southern terminus of the glacier flows and is crossed by many terminal moraines. The river profile shows a fall of approximately 4 ft. to the mile. The greater portion of the drainage area is cleared land under cultivation, with the run-off conditions somewhat intensified by thorough systems of tile underdrainage. The mean annual rainfall is 36½ in.

The Flood of 1913. The flood of March, 1913, was the greatest on record in the Miami valley. It was one of a series of violent manifestations of energy coming in a month of most unusual weather conditions all over the country. Evidences of the storm conditions appeared in California on March 20. Moving rapidly eastward, and gathering intensity as it traveled, it gave expression to its force in the shape of destructive tornadoes in Omaha, Neb.,


SIDNEY
LOGAN CO.
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CLARK CO.
MONTGOMERY CO.
MIAMI CO.
PREBLE CO.
MONTGOMERY CO.
GREENE CO.
DAYTON
MIAMISBURG
MONTGOMERY CO.
BUTLER CO.
WARREN CO.
MIDDLETOWN
HAMILTON
LEGEND
FLOOD CONTROL WORK
CITIES AND TOWNS
VILLAGES
STEAM RAILROADS
ELECTRIC RAILROADS
ROADS
STREAMS
SCALE OF MILES

FIG. 1.

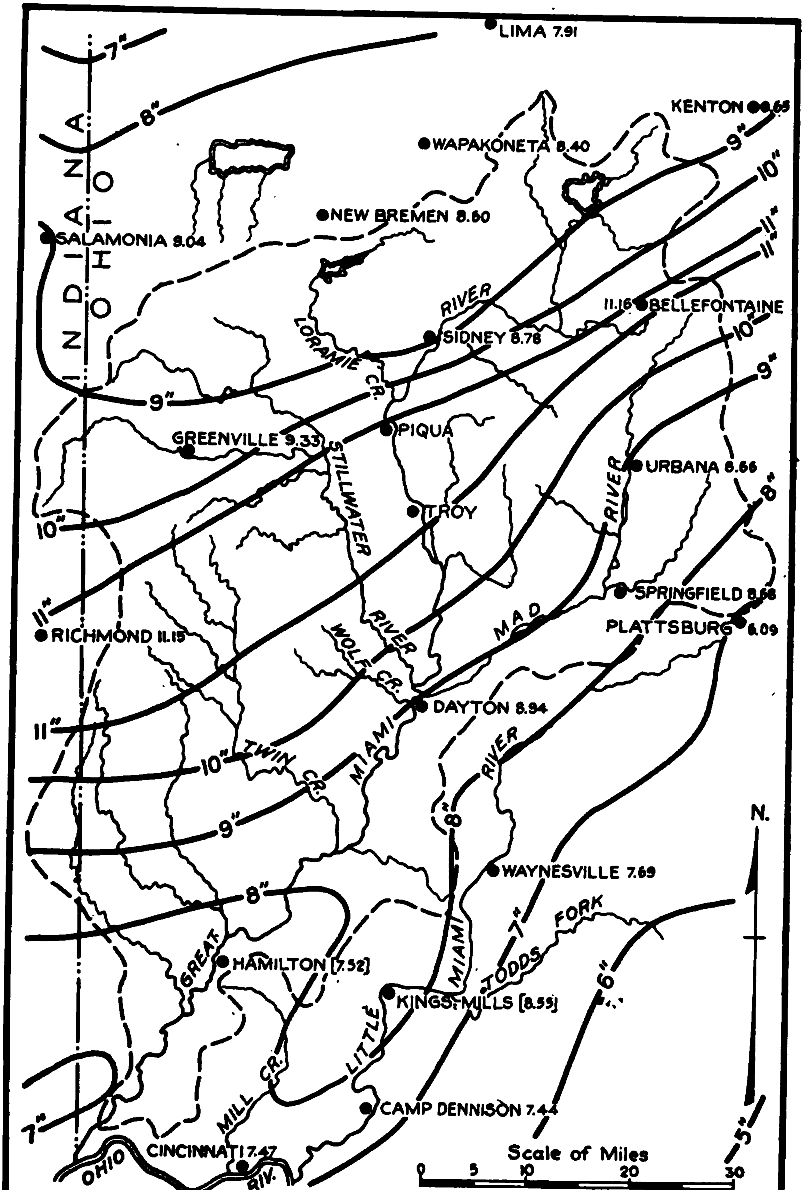


FIG. 2. RAINFALL, MARCH 23–27, 1913.

Davenport, Ia., and Terre Haute, Ind. Rain began to fall in the Miami valley on March 23 and lasted until the 27th, although on the first and last days the rainfall was comparatively light. A map of the region, with the total rainfall during the storm shown by isohyetal lines, is shown in Fig. 2.

The conditions at the time of the storm were especially favorable for a large and rapid run-off. Although there was no snow the ground was soaked and practically frozen, and the time of year was one of low evaporation. While during an average year in the Miami valley one third only of the rainfall appears as stream flow, in the great flood of 1913 the run-off was about nine tenths of the rainfall. The flow of the river at Dayton, with a drainage area of 2 500 sq. miles reached a crest of 250 000 sec. ft., or 100 cu. ft. per sec. per sq. mile.

The destruction caused by the flood was appalling throughout practically the entire valley. About 400 people lost their lives, and the property damage has been variously estimated at from 60 million to 150 million dollars.

Flood Prevention Measures. Stunned but momentarily by the shock, the residents of the devastated districts, with the wonderful recuperative powers of the Middle West, proceeded at once to organize and plan to prevent a recurrence of the disaster. At first the various settlements of the valley worked along independent lines, each seeing only its local problem. But it soon became apparent that the task of securing adequate protection was one which could be worked out to a successful conclusion only by combining the interests of all parties concerned. No one city could accomplish the result for itself without an expenditure that would be prohibitive. Recognizing this condition, the Conservancy Law of Ohio was passed February 6, 1914, about eleven months after the flood.

The Conservancy Law is such a distinct step forward along the lines of coöperative effort looking toward great public improvements that perhaps a word as to its operation may not be remiss. The Miami Conservancy District is composed of the nine counties directly affected by the improvement. Each county is represented in the Conservancy Court by its judge of the Court of Common Pleas. Sitting as a body this court, on June 28, 1915, voted to

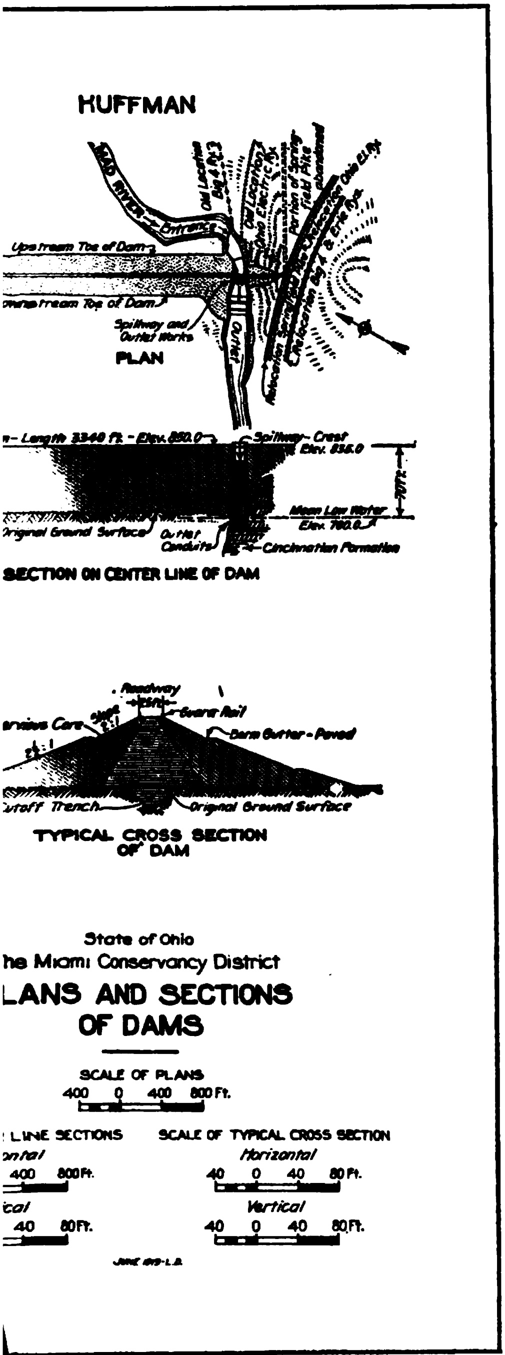
FIG. 3. THE FLOOD WATERS ENTERING THE BUSINESS DISTRICT.
At the crest of the flood the water stood level with globes on street lamps.

FIG. 4. THE FLOOD IN THE RESIDENTIAL DISTRICT.

create the district, and appointed three directors with executive powers to proceed with a program of flood protection for the valley. The court also appointed three appraisers to evaluate the damage and benefits resulting from the improvement. Fig. 6 illustrates the operation of the law, and follows in more or less detail the various steps necessary before construction can be started.

FIG. 5. AFTER THE FLOOD.

The Official Plan. A thorough investigation of practically every conceivable scheme of flood protection was made. The final result showed that the real solution lay in limited channel improvement and levees through the cities, supplemented by a system of retarding basins, the function of the retarding basins being to hold back temporarily the flood flows and allow them to escape into the river channels below at such a rate only as the improved channels can accommodate. A delicate adjustment of the relative capacities of the component parts of the system was necessary, and the balance between what could be done along the line of


HUFFMAN
Upstream Toe of Dam
ownstream Toe of Dam
Spillway and Outlet Works
Entrance
Outlet
PLAN
SECTION ON CENTER LINE OF DAM
Spillway Crest Elev. 835.0
Mean Low Water Elev. 780.0
Original Ground Surface
Outlet Conduits
Cincinnatian Formation
Roadway
Guard Rail
Berm Gutter - Paved
Cutoff Trench
Original Ground Surface
TYPICAL CROSS SECTION OF DAM
State of Ohio
he Miami Conservancy District
LANS AND SECTIONS OF DAMS
SCALE OF PLANS
400 0 400 800 Ft.
LINE SECTIONS
SCALE OF TYPICAL CROSS SECTION
Horizontal
400 800 Ft.
40 0 40 80 Ft.
Vertical
40 80 Ft.
40 0 40 80 Ft.

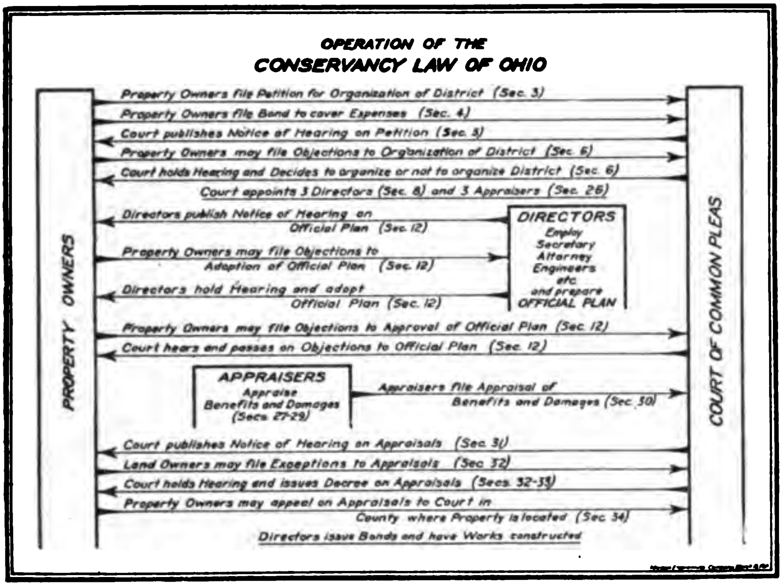


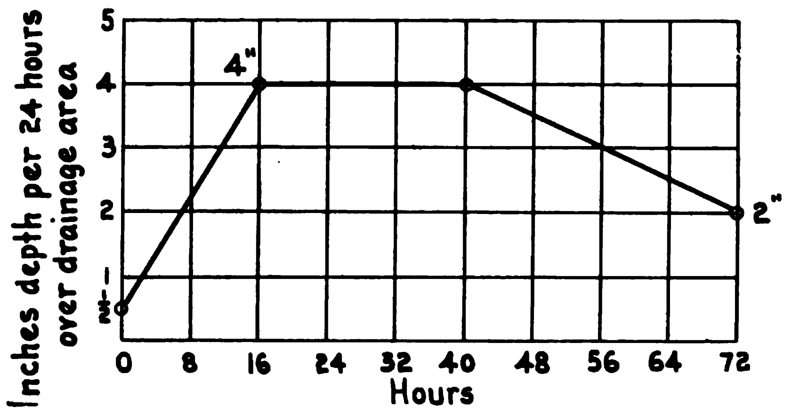
FIG. 6.

improving river channels and what was necessary in the way of reservoir storage was the subject of thorough and prolonged study. The final decision called for five retarding basins, the locations of which are shown on the general map of the district, Fig. 1. The principal dimensions of the dams, together with correlative data, are shown in Table 1, while plans and sections appear in Plate I.

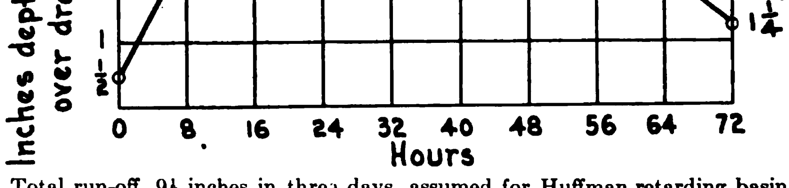
As a result of the study of rainfall conditions in the Miami valley the capacities provided for in the retarding basins are based upon a possible run-off of 10 in. in three days for the Englewood, Germantown, and Lockington basins, and 9½ in. in three days for the Taylorsville and Huffman basins. The theoretical flood run-off curve was drawn upon the assumption of a 16-hour rise, a 24-hour constant peak, and a 32-hour fall. At the beginning of the flood the run-off was assumed as one half inch per 24 hours over the drainage area; at the peak, as 4 in. in the 9½-in. run-off basins and 4½ in. in the 10-in. run-off basins, and at the end of the flood as 2 in. in 24 hours over the drainage area for the 9½-in. basins and 1¼ in. for the 10-in. basins. The foregoing will be

clear by an inspection of Fig. 7. Protection is provided against a flood 40 per cent. greater than that of 1913 before the spillways will come into action, and twice as great as 1913 before the dams will be overtopped.

As illustrative of the effect of a retarding basin upon a great flood, Fig. 8 is shown. Here is seen the reduction that would have occurred in the flow of the Stillwater River at Englewood had the



Total run-off, 10 inches in three days, assumed for Germantown, Englewood, and Lockington retarding basins.



Total run-off, 9½ inches in three days, assumed for Huffman retarding basin and for drainage area above Taylorsville but below Lockington.

FIG. 7. THE MIAMI CONSERVANCY DISTRICT ASSUMED RUN-OFF DIAGRAM.

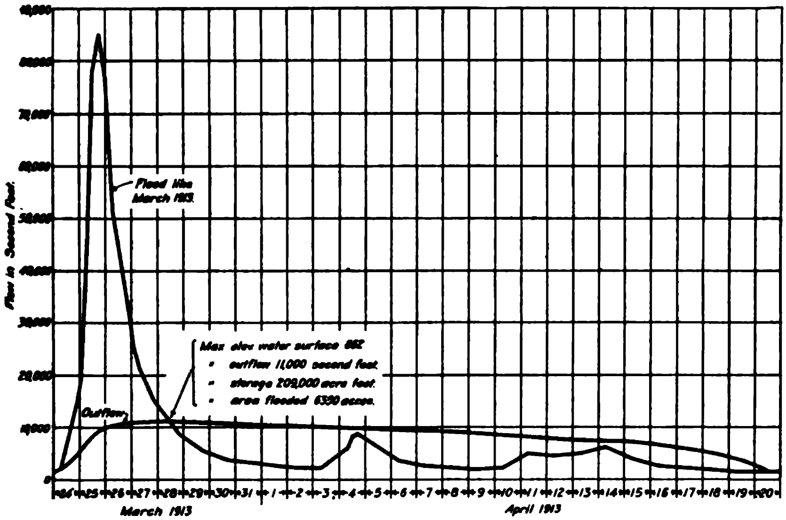


FIG. 8. HYDROGRAPHS SHOWING SIZE OF FLOOD OF MARCH, 1913, AT ENGLEWOOD RETARDING BASIN, AS COMPARED WITH THE RATE OF OUTFLOW FROM THE BASIN IF IT HAD BEEN IN EXISTENCE.

dam been in service during the great flood of 1913. The combined effect of the four retarding basins above Dayton is figured to reduce the flow through that city, should a flood equal to that of 1913 occur, from 250 000 sec. ft. to 110 000 sec. ft. Similarly, the effect of the five basins above Hamilton would be to reduce the flow from 354 000 sec. ft. to 200 000 sec. ft.

As soon as the general scheme for flood prevention was formulated, subsurface investigations were begun, looking to the development of underground conditions at all of the proposed dam sites and elsewhere in the district where large construction was contemplated. In conjunction with a recognized authority upon the subject, the local geology was studied. Borings, both in earth and rock, were put down in sufficient number to reveal the foundation conditions for dams and appurtenant structures. Ledge rock was located upon which to build the spillways and conduits, and this rock was thoroughly investigated. Borrow pits, both for embankment materials and for concrete aggregates, were developed and exhaustive tests made of their products. Earth samples, taken by the dry method, and rock cores were preserved in cabinets

for use by the designing division and for inspection by prospective bidders. Preparatory to starting borings, each dam site was laid out in a system of coördinates, the origin of which was sufficiently south and west of the area to be prospected to insure all designations of being north and east. The boring holes were given a fractional designation, the numerator of which was the number of hundred feet north and the denominator the number of hundred feet east of the origin of coördinates. Each such number was preceded by a letter indicating the dam site. Thus E 24/40 would designate a boring at the Englewood dam site, 2 400 ft. north and 4 000 ft. east of the origin of coördinates. While the location as given by the fractional designation was not necessarily exact, it was sufficiently close to render great assistance in looking up borings on the map.

In addition to the boring investigations, samples of sand and gravel were collected from all of the dam sites and tested to determine their value for use as concrete aggregates. Also, the proposed borrow pits were sampled and mechanical analyses made of the material to be used for the hydraulic fill. Material passing the 200-mesh sieve was subjected to such tests as would determine its suitability for use as the core of a hydraulic fill dam. Particularly were such "fines" compared as to rate of settling, etc., with core material from hydraulic fill dams in other parts of the country.

The natural conditions at all of the five dam sites dictated the adoption of the earth type. Ledge rock occurs at one side of the valley only, in each case, while deposits of glacial débris, admirably suited for hydraulic sluicing, are found in abundance at favorable locations. The cross-section adopted for all of the dams is shown in Fig. 9, the width of core material in the center being arbitrarily assumed at any particular elevation as equal to the distance down from the top of the dam. Where the foundation material was porous a 4-ft. blanket of impervious material was placed to increase the ratio of length of travel of seepage to head of water.

Each dam is provided with a concrete spillway, about 15 ft. down from the crest, and with outlet works. At Englewood and at Germantown the openings are in the form of covered conduits through the dam at the old river channel, with a separate spillway

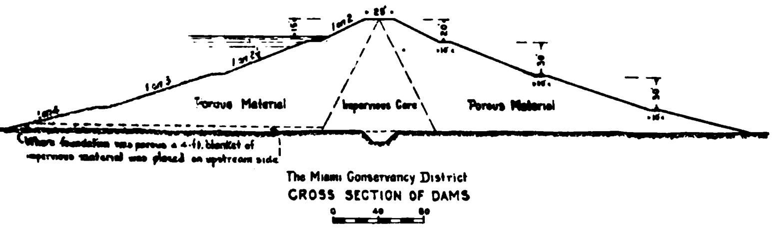


FIG. 9.

structure near the end of the dam. At Taylorsville, Huffman, and Lockington the spillways are in the form of an ogee weir located also at the old river channel, having suitable openings near the base to accommodate the stream flow. Figs. 10 and 11 show typical examples of the two types of structure.

One of the distinct problems in the design of the dams was in connection with the issuing jet from the outlet conduits. In flood conditions velocities of 50 or 60 ft. per second are to be expected. To allow any such onrush of water to project itself into an unprotected river channel would be to invite disaster and endanger the dam itself. A search for literature upon the subject brought forth little that was directly applicable. While the principles of the

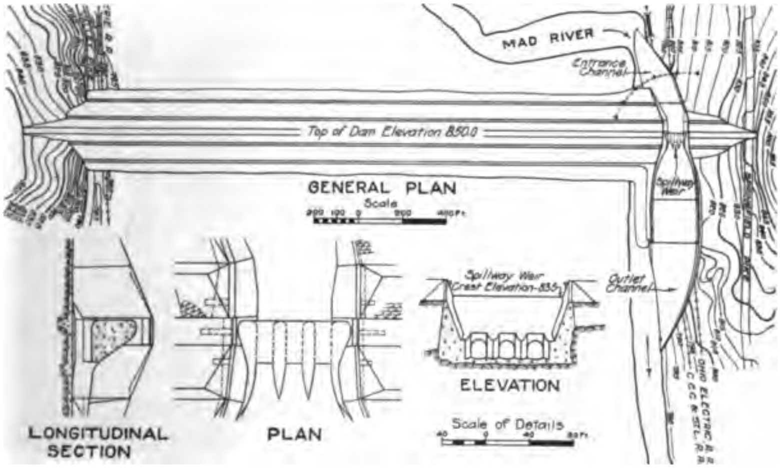


FIG. 10. GENERAL PLAN OF HUFFMAN DAM, OUTLET CONDUITS, AND SPILLWAY; AND ENLARGED PLAN, ELEVATION, AND LONGITUDINAL SECTION OF COMBINED CONCRETE SPILLWAY WEIR AND OUTLET WORKS.

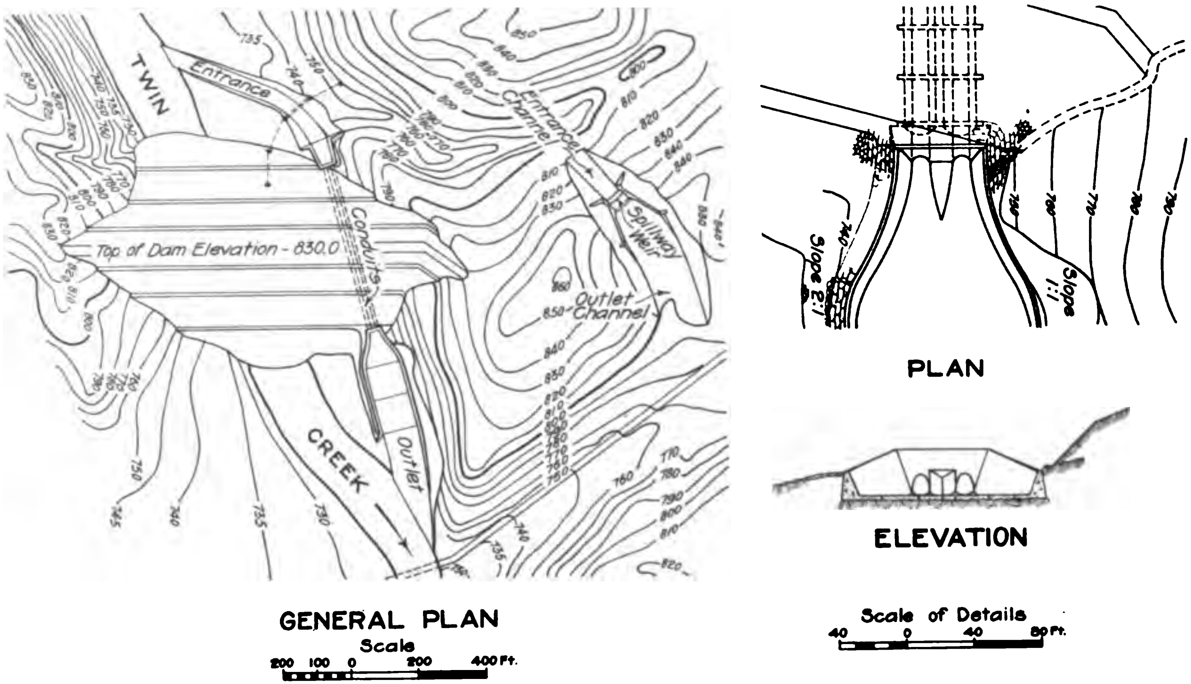


FIG. 11. GENERAL PLAN OF GERMANTOWN DAM, OUTLET CONDUITS, AND SPILLWAY; AND ENLARGED PLAN AND ELEVATION OF LOWER END OF OUTLET WORKS.

hydraulic pump were looked upon as the solution of the problem, the difficulty lay in so fashioning an outlet from the conduits that these principles would properly function in practice. Theoretical conclusions were not to be entirely relied upon without corroboration from experimental sources. Accordingly, a hydraulic laboratory was established upon the estate of Col. E. A. Deeds, president of the board, and it was largely through his generosity that the facilities for conducting the investigations were available. A model of the conduits of one of the dams was constructed to scale, and various types of outlets were experimented with under different conditions of flow. Baffle piers, similar to those at the Gatun Dam, were tried with various modifications; devices for spraying the water into the air and others for turning the streams against each other were studied, but the conclusion was finally forced upon those conducting the experiments that the most practicable method, under the conditions, of dissipating the energy of swiftly flowing water lay in the hydraulic pump. The shape of outlet adopted as the result of these studies consisted of a flaring basin, confined by high concrete walls, with a bottom sloping away from the outlet in steps, terminating in two baffle walls or weirs. A general idea of the arrangement may be had from an inspection

FIG. 12. OUTLET FROM ENGLEWOOD CONDUITS.

of Fig. 12. A full discussion of the foregoing experiments has been published as Part 3 of the Technical Reports issued by the Miami Conservancy District.

CONSTRUCTION.

Information for Bidders. Throughout the preparations for construction the thought was kept firmly in mind that if intelligent bids upon the work were desired as complete information as possible in reference to conditions to be encountered should be available. No haphazard guesses would be welcomed, but only such figures were desired as represented the mature judgment of experienced persons, based upon a thorough knowledge of working conditions and representing a square deal to both contracting parties. The fact that industrial conditions, due to the war, rendered it inadvisable to do the work by contract did not in the least detract from the usefulness of the assembled data, for the information available has proven of inestimable value to the engineering force in the planning and supervision of the work.

As a preliminary to inviting contractors to bid on the construction work, a pamphlet entitled, "Information for Bidders" was published as a separate volume from the contract and specifications, the idea being that in this form interested parties could, by perusing a comparatively inexpensive publication, obtain the necessary information to enable them to decide whether or not they desired to prepare a bid. Contained in the Information for Bidders were a list of proposed contracts, directions for properly preparing a bid, information in relation to local supplies of material, laws, public service conveniences, statements of quantities, etc. There were also general maps of the district, rainfall charts, and river hydrographs.

Copies of the Information for Bidders were distributed in such a manner as to secure the attention of the maximum number of desirable bidders; but the entrance of the United States into the war, with the attendant labor and material conditions, so unsettled the minds of contractors that only a few submitted bids. And, of those bids received, one only, a proposal for levee work, was in such form as to warrant acceptance.

Organization. As a natural result of the inability to close satisfactory contracts, the board decided to proceed with the work by force account. The organization was to be under the supervision of A. E. Morgan, — who as president of the Morgan Engineering Company had been in charge of the project from its inception, — chief engineer, and Chas. H. Paul, assistant chief engineer, with a division engineer and the necessary engineering assistants and clerical forces at each dam.

But it was desired to preserve as fully as should seem advisable the usual functions of contractor and engineer. To do this the office of construction manager was created. An effort to secure the very best talent available for this important post resulted in the appointment of Chas. H. Locher, a contractor of national reputation, who needs no introduction to the members of this Society. Mr. Locher's wide experience and resourcefulness have proven of inestimable value to the work. In practice it has developed that the relations of engineer and construction manager exist more in the nature of a copartnership, there being no tendency to place any hard-and-fast limitations upon the duties of either. So well has this plan of organization functioned in the year and a half of construction to date that no change of any sort has even suggested itself.

Specifications. A separate set of specifications for each contract was not written. Such procedure would have resulted in considerable duplication. Instead, the entire construction program was analyzed into classes of work, and each class given an item number. Specifications relating to each item were written and assembled into two volumes, one for the five dams and one for the channel improvement projects at Dayton and Hamilton. Only such items as were applicable to the particular work were included in each volume.

The specifications fall into three parts: — first, the General Conditions, Sections 0.1 to 0.57, governing the relations of the contractor to the district, to the public, and to his employees; second, the General Specifications, Sections 0.58 to 0.105, defining and classifying the most commonly used materials, and indicating in general how the work shall be done; and third, the Detail Specifications, Sections 1.1 to 90.2. The Detail Specifications by

supplementing the Agreement, General Conditions, General Specifications, the Estimates, and the Drawings, define in detail how each kind of work shall be done, and how it will be measured for payment.

The different kinds of construction work to be done and of materials to be furnished are classified into items, an item meaning a certain kind of work to be done, or material to be furnished, in a certain definite manner, regardless of its location. Each item is designated by a name and number, the numbers running from 1 to 90, as Item 2, Clearing and Grubbing, or Item 51, Reënforcing Steel. All sections relating to any item bear the number of the item as an index number before the decimal point. For instance, Item 50 covers cement, Section 50.1 gives the requirements as to brands, Section 50.2 specifies the manner of delivery and storage, Section 50.3 covers inspection, tests, etc., and Section 50.4 specifies the methods of determining quantities of cement for payment.

All item numbers with letter "a" affixed refer to work below mean low-water level as indicated on the drawings. For instance, Items 41 and 41a include concrete in outlet works, spillways, retaining walls, bridge piers, and other similar structures, above and below mean low water, respectively. The same item may be met on various parts of the project. Wherever in the estimates or on the drawings "Item 41" is indicated, regardless of whether it occurs in channel improvement at Hamilton, or in the construction of the Englewood Dam, or in some other construction, the work to be done is the placing of concrete in accordance with the Specifications under Item 41, supplemented in all cases by the General Specifications, which apply to all items. Item 41a refers to the same kind of construction as Item 41, except that the work is located below mean low water, as shown on the drawings.

In brief, the General Conditions and General Specifications relate, in so far as they are applicable, to all work. The estimates and the drawings indicate under what item or items any particular part of the work is to be done, and specifications for that item give the necessary further directions for doing that particular work.

An attempt was made in the phraseology of the specifications to depart from the time-honored custom of making the contractor responsible for everything under the sun. In the first place, it was

the intention of the authors of the specifications that the obligations of both contracting parties be defined with such clarity that any possibility of wrangling or future litigation be eliminated. Clauses were not inserted for no better reason than that they occurred in some other "standard" specification. Obligations, which it was never intended that the contractor should assume, were not embodied, with the idea that they might, sometime, come in useful. No attempt was made to endow the engineer by edict with autocratic powers, regardless of what the courts always say about such procedure. In short, the fact was constantly held in mind that there were two honorable contracting parties, each with his rights and obligations, and, while the engineer was shorn of none of the authority or right of decision necessary for the successful prosecution of the work in accordance with the desired standards, such power was not given to him arbitrarily, but in strict accordance with well-defined principles clearly stated in the contract and specifications.

Particular attention was paid to the form of bond, and, while no requirements were embodied that may not be found in the standard forms in use by leading bonding companies, the form of bond adopted was designed to provide the greatest protection to the district without imposing upon the securities any unreasonable obligations.

To give the fullest possible opportunity to local bidders, who might not in some cases be possessed of great resources, the proposed work was divided into as large a number of separate contracts as seemed compatible with rapid progress and efficient execution. At the same time, in order not to discriminate unduly against the larger contractor, provision was made to receive bids upon different contracts in combination. By this means a contractor possessed of larger means and equipment could bid upon the work in large units without incurring the danger of being awarded only small or isolated parts of the work.

To fully draw upon the industrial resources of the community the following notice was embodied in the advertisement:

"*Notice to Subcontractors.*

"The larger contracts to be let contain numerous smaller pieces of work for which the main contractor may not be equipped, and which he may desire to sublet. The chief engineer of the Conservancy District would be pleased to hear from any persons or firms who would be in position to take any of these subcontracts, and will put them in touch with those who will bid on the larger contracts as a whole. On the reverse side of this sheet is a blank form which may be filled out by those interested. Some of the kinds of work which may be included in these subcontracts are: . . ."

(Here follows a list of work such as a small contractor might undertake, and forms for filling in his resources, qualifications, equipment, etc.)

Power. Owing to the location in the vicinity of Dayton, convenient to the five dams, of a large commercial electrical power plant, this form of power was decided upon for use wherever feasible. It is expected that the Conservancy demand will be upward of 8 000 h.p. To distribute this, the power company set over 2 000 poles and strung more than 200 miles of copper wire. The greatest distance of transmission is to the Lockington Dam, 40 miles from the power station. Alternating current at 6 600 volts is generated at the power station, transmitted at 33 000 volts, stepped down to 2 300 volts at each dam-site substation, and distributed to the motors at 440 volts and to the lighting system at 110 volts. An exception is made in the case of the motors for the large dredge pumps, which receive their current at 2 300 volts. All electrical power is 3-phase, 60-cycle, alternating current. The rate paid for current is in accordance with a sliding scale based upon quantity used and the maximum demand. At Englewood, using 500 000 kw.-hrs. monthly, the rate has been slightly under 1.6 cents per kw.-hr.

Plant. One of the serious questions involved in the starting of a large construction job in war times was the assembling of the necessary plant. However, the War Department declared the work an essential war industry and gave favorable priorities. Their justification for doing this lay in the fact that the territory to be protected by the proposed improvement embraced a vast number of important manufacturing plants for war materials as well as a large aviation field and training station for fliers. By this means

it was possible to secure without serious loss of time items of plant and equipment, the lack of which otherwise would have made it impossible to begin active operations.

Camp. As only the most meager housing facilities existed in the vicinity of the proposed dams it was decided that proper provisions should be made by the Board for the comfort and welfare of its employees. And it was felt that no mere collection of shacks would suffice for the class of labor it was hoped to attract. Accordingly the topography of the land available for camp purposes was carefully studied, and an expert in city planning retained to lay out at each dam a village which, after construction should end, would have permanent value. The result has been most satisfying. At each dam is an attractive village, with its cottages, schoolhouse, mess hall, store, first-aid station, and community hall. The latter was usually some existing building adapted to the purpose. Large barns or tobacco sheds were remodeled into bunk houses, where the single men can find living accommodations. In general, the bunk houses are arranged with a long corridor, off which are the rooms. Each room holds a double-decked steel cot, and every room has an outside window. All cottages, bunkhouses, etc., are provided with shower baths. The camp has a modern sewer system. The result has been that employees are provided not only with a house but with a home, and instances have come up where attractive offers of employment elsewhere have been refused by residents of the camp who have preferred not to move.

The community spirit at each of the dam-site villages is evidenced by the fact that each camp has its local self-government. All residents of the camp are eligible for membership to these associations. With various modifications, the commission-manager form of government is used. All matters of local interest, including general welfare, are decided by the community government.

At each of the dam sites a school teacher is employed by the Board, and a schoolhouse provided. The schools are following the most advanced methods, and are establishing a reputation for themselves. Applications for enrollment have come even from residents of the neighboring country who have no connection with the Conservancy work.

Soil Stripping. An early operation in the construction of the dams was the soil stripping. The specifications required the removal of all vegetation, stumps, roots one inch or more in diameter, and any unsuitable matter. The method of doing this at Englewood will be described as fairly typical. Excavation was by means of an elevating grader of standard make, hauled a portion of the time by a large tractor and the remainder by 16 mules, four in lead, six on pole and six in rear. These were served by 14 three-up bottom-dump wagons. The material was stored in windrows just outside the toes of the dam, to be later spread over the graded slopes as soil dressing.

Work was done during the summer months. There were 56 possible working days and 47 actually worked, a loss of time of 16 per cent., due to weather. The average loaded haul was from 150 to 200 ft. The material moved aggregated 45 000 cu. yd., and the depth of cut was about 7 in., or one plowing. The daily yardage moved averaged 945 cu. yd. working a 10-hr. shift.

Outlet Works. At each of the dams attention was focused first on the construction necessary to divert the river. This was accomplished at Englewood and Germantown by means of the concrete outlet conduits; at Taylorsville, Huffman, and Lockington the bottom and sidewalls only of the spillway are being built, leaving the weir to be placed later and forming a large flume which permits the unobstructed flow of the river.

The Englewood outlet structure has a total length of 1 060 ft., of which 709 ft. is a double-barreled covered conduit. A cross-section at its maximum thickness, under the center portion of the dam, is shown in Fig. 13. As the conduits approach the toes of the dam, with the depth of cover correspondingly reduced, the thickness of crown and sidewall are gradually lessened, becoming 15 in. and 18 in., respectively, at the downstream toe, and 18 in. and 24 in., respectively, at the upstream toe.

During the construction period the full opening of the conduits will be utilized for the flow of the stream, but when the dam shall have reached such a height as to be safe from overtopping from floods the lower portion will be filled with compact sand and gravel and the permanent floor constructed, reducing the area of the waterway to its figured size.

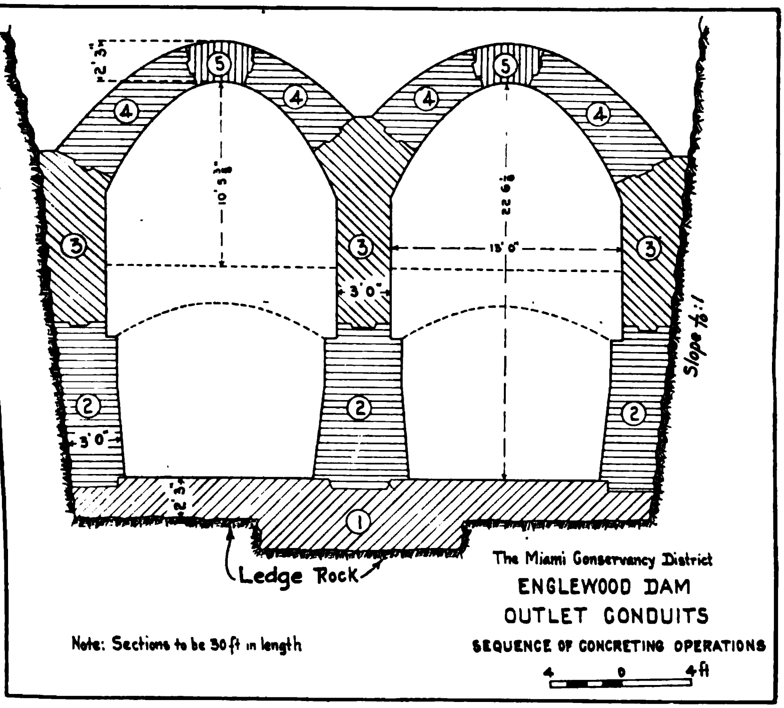


FIG. 13.

The conduits are founded entirely in rock, known geologically as Cincinnatian Formation. It consists of layers of hard, highly fossilized limestone, ranging from one to four inches in thickness, interstratified with layers of hard clay or soft shale. Upon exposure to the air the clay and shale content rapidly disintegrates. In the geological scale the formation is found in the upper reaches of the Ordovician (Lower Silurian) Period.

Excavation on the outlet works was begun May 10, 1918, and continued to November 13, 1918, during which time 8 000 cu. yd. of earth and 58 000 cu. yd. of rock were excavated. The material was handled by means of a 115-ton steam dragline excavator of standard make, equipped with an 85-ft. boom and a 5-yd. bucket. The machine would back along the line of the conduit, digging behind itself as it moved, and depositing the material into 12-yd.

air-dump cars on standard-gage track. A portion of the excavated material was dumped into a waste pile located along the river downstream from the dam, and the remainder, principally rock, was placed at the downstream toe of the dam near the outlet from the conduits, to serve as a buffer to prevent the backwash from the outflow reaching the toe. The operation of the dragline necessarily left the surface of the rock cut in a ragged condition, with numerous projecting fragments of loose rock. As it is necessary that the concrete of the conduits form contact with absolutely solid rock, final trimming by hand-quarrying methods was done just previous to concreting.

The dragline method of excavating works down to grade with a single face, and thereby enables concreting to start before completing the cut for its full length. Concreting at Englewood began August 10, 1918, and was finished June 7, 1919. A total of 19 000 cu. yd. were placed. Due to the unusually mild winter, the work proceeded with practically no interruption.

The cement used was of a well-known brand and was tested by a laboratory of established reputation. No cement failing to pass the recognized standard requirements was released for shipment to the work. Sand and gravel were obtained from the main borrow pit by the large draglines sending material to the dam, and, part of the time, by a smaller dragline operating solely for that purpose. The material was hauled in the regular 12-yd. dump cars to the combined screening and mixing plant located near the inlet end of the conduit. Here the aggregates are separated into three sizes, — coarse gravel, from 1½ in. to 3 in. diameter; fine gravel, from ¼ in. to 1½ in. diameter; and sand, all material from ¼ in. down. The arrangement of the plant is shown in Fig. 14. The separation of the coarse aggregates into two sizes was not so much for the purpose of combining them later into some ideal grading curve but rather to prevent the segregation which takes place in the bin, particularly when it is drawn well down, from delivering to the mixer a whole batch of improperly graded stone. This arrangement worked out very well in practice, as it enabled the grading to be varied at will. An instance of this occurred in starting a day's run, where it was desired to use the smaller stone until a cushion of concrete had been deposited into which the

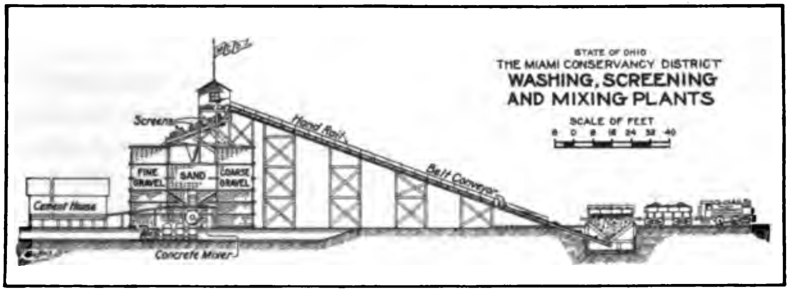


FIG. 14.

coarser aggregate could imbed itself properly. Having the two sizes of coarse aggregate in separate bins also enabled the concrete in the arch sections to be proportioned with a preponderance of the small-sized stone.

The mineral composition of the aggregates was well known,—principally limestone, with a sprinkling of the Canadian granites brought down by the glaciers. And the concrete- and mortar-making qualities of these aggregates had been satisfactorily ascertained by many tests. Accordingly, during construction it was necessary to watch only the cleanliness of the gravel and the sand and the grading of the sand. The condition of the gravel was apparent by inspection. Each day a sample of sand was taken as it entered the mixer. A part of this was washed to determine the silt content, and a portion was run wet through the Universal Tester and its mechanical analysis plotted on a whiteprint upon which appeared the mechanical analyses of all sands tested during the preliminary investigations and found acceptable. Not much concern was felt on this score, as no sands investigated failed to equal standard sand, and by far the greater number exceeded it in the 2-in. mortar cubes. The careful inspection of aggregates developed one feature in the gravel-washing plant, a failure to detect which would have led to unfortunate results. In a plant of this kind, where the material goes from the screens into the bins and thence direct into the mixer, it was found that the washwater clinging to the separate stones carried in suspension an infinitesimal amount of silt which settled in the bottom of the bin and, in time, caused a deposit of mud which coated the stones. The remedy lay

in emptying the bins when this became noticeable, discarding the dirty gravel.

The aggregates flowed by gravity from the belt conveyor into the screens and through the bins into the mixer. The chutes from the stone bins to the mixer were covered on top and were gaged to serve as measuring boxes for the aggregates. Gaging the sand was deemed of the utmost importance, and for this purpose a measuring box was interposed between the sand chute and the mixer hopper. This box was roughly in the shape of a cube standing on its corner, with the top and bottom corners cut off, the top to fill and the bottom fitted with hinged doors to empty. In this manner the area of the mouth was made as small as possible and, as the proportion of sand called for a full box, any slight inaccuracy in striking off would have little effect on the resultant volume.

A refinement entering into the construction of the conduits was in the adjustment of the amount of cement entering into the concrete used in the various parts of the structure. For instance, in the faces of the retaining walls of the inlet and outlet, at the level where the water will stand during the greater part of the winter, a richer mix was used for a foot or so back from the face. This was to give the concrete at this particular place additional resisting qualities against the disintegrating tendencies of the freezing water. Similarly, in all wide retaining walls, the faces of which are exposed to swiftly flowing water, more cement was used in the mixture along the face than in the backing of the wall.

The foregoing adjustment of mixtures was, of course, in addition to the proportions normally determined upon for various parts of the structure, depending upon the work the particular concrete is called upon to do. Inasmuch as the cement is by far the most costly ingredient entering into the mixture, it is obvious that its content shall be as low as practicable without chancing to sacrifice any of the qualities essential in the finished product. Following this reasoning a number of standard mixtures were selected. In all cases the amounts of sand and gravel were constant; the variation in the mix being governed by the number of sacks of cement added. Thus, a 5-bag mix gave proportions by volume of 1: 2.8: 5.6 and an 8-bag mix gave proportions of 1:1.75:3.5. The latter mixture was used in the covered portion of the conduits, where the

concrete in extreme flood conditions will be in contact with water flowing at a velocity of 60 ft. per second.

At frequent intervals cylinders of concrete, 6 in. in diameter and 6 in. long, were cast from the material as it was being placed. The reason for selecting this size cylinder, rather than the standard 8 by 16 in., was that it represented the capacity of our testing machine. The cylinders were stored in damp sand or sawdust until ready for breaking. The results of the tests at Englewood appear in the following table:

Sacks.	Proportions.	Number of Specimens.	Compressive Strength in Lbs. per Sq. In. at 3 Months.
5	1:2.8:5.6	15	2 280
6	1:2.33:4.66	30	2 573
7	1:2:4	6	3 300*
8	1:1.75:3.5	9	3 300*

* Exceeded capacity of machine.

When it is considered that the concrete will not be called upon to sustain stresses in excess of 500 lb. per sq. in., it will be seen at a glance that no apprehension need be felt on this score as to the safety of the structure. The average cement factor for the entire 19 000 cu. yd., in bbl. per cu. yd., was 1.57.

In order to provide for internal stresses in the concrete due to temperature and shrinkage, and partly to facilitate casting, the conduits were built in 30 ft. sections longitudinally and brought to their full height in several separate operations. This will be made clear by reference to Fig. 13. Collapsible wooden forms, which could be used repeatedly throughout the life of the concreting operations, were devised by the designing division. For the retaining walls, panels, cantilevering from the finished concrete as the walls progressed upward, were used. All forms gave excellent service and were still good at the end of the job.

Concrete was mixed in one-yard batches, the mixer emptying into side-door hopper cars on 3-ft. gage. The concrete track ran close to and parallel with the conduit excavation and was at such elevation that the greater portion of the concrete could be chuted directly into place. The concrete cars were hauled by a 3-ton gasoline locomotive, which gave uniformly excellent service throughout. In fact, this locomotive was one of the most pleasing items of plant on the job.

FIG. 15. ENGLEWOOD OUTLET CONDUITS.
Showing also old river bed prepared for embankment.

FIG. 16. ENTRANCE TO ENGLEWOOD CONDUIT.

The outlet conduits at the Germantown Dam are 546 ft. long, exclusive of the inlet and the outlet, and contain 15 000 cu. yd. of concrete. Their construction followed very closely the methods in use at Englewood. No unusual conditions were encountered, and the structure is now completed.

At the Lockington Dam the problem was entirely different from Englewood and Germantown. While the latter two structures are of the covered-conduit type, the Lockington outlet works consist of an ogee weir, through the lower portion of which are two openings, 9 ft. wide and 9 ft. 2 in. high, for the normal river flow. For stream-control purposes during construction the bottom and side walls only of the structure were built, leaving the spillway weir to be placed after the embankment of the dam shall have reached sufficient height to be safe from overtopping during flood flows of the river.

The Lockington outlet works are founded upon Cedarville limestone. The top of ledge rock was close to grade, and slight excavation only was required to provide a suitable foundation. Some grouting was necessary, however, owing to the presence of cavities, such as are commonly found in limestone of this sort.

The structure as built to date contains about 28 000 cu. yd. of concrete. Excellent sand and gravel for concrete were found in the excavation, the material being handled by means of a large dragline. The screening and mixing plant were essentially the same as those for all five of the dams and mentioned in more or less detail in the description of the Englewood conduits. The concrete was transported in 1¼-yd. bottom-dump buckets on platform cars drawn by a gasoline locomotive and placed by two large steel derricks. Wooden cantilever panel forms were used.

The construction of the outlet works at the Huffman Dam is, in all essentials, similar to that at Lockington. The structure is similar and the methods followed do not differ sufficiently in detail to merit separate mention.

The Taylorsville outlet works are of the ogee weir type, similar to Lockington and Huffman. For their construction they require, however, very much more excavation. This work is now in progress. The quantities to be moved aggregate 500 000 cu. yd. earth and 350 000 cu. yd. rock (Cincinnatian Formation). At

this writing (September 1) the excavation is 40 per cent. completed. The material is being handled by a large electric dragline, equipped with a 100-ft. boom and a 3½-yd. bucket and loaded into standard-gage 12-yd. air-dump cars for transportation across the river, where the rock is dumped into the toes of the dam. It is expected that concreting at Taylorsville can be started about October 1.

Hydraulic Fill. The total embankment in all five of the Conservancy dams will aggregate in the neighborhood of 8 000 000 cu. yd. Practically all of this will be placed by the hydraulic method.

The first important consideration in the program of construction was the problem of stream control. It must be kept in mind that these dams are situated above large centers of population, where any sudden release of impounded water would spell disaster. Therefore the sequence of operations must be so planned as to be safe beyond a reasonable doubt, even should a repetition of the great 1913 flood occur. This is done in two ways, depending upon the type of outlet works. At Lockington, Huffman, and Taylorsville the outlet works, as previously stated, are simply openings through the lower portion of the spillway weir. It is, therefore, a simple matter to construct the bottom and side walls of the structure, making an admirable flume for the passage of water. The weir itself is not built in until the dam has reached a safe height. For the covered-conduit type of outlet works, as at Englewood and Germantown, however, the stream-control problem is vastly more difficult. Here it is necessary to retain the original waterway or provide an artificial one until such time as the adjacent portions of the dam can be carried up to an elevation of safety, and subsequently to make the closure during the season of low flows. At Germantown the problem is simplified by the narrow valley, and the yardage involved in raising the embankment clear of the danger point is sufficiently small to permit the river closure to be made this season. In fact, the work is now going on. These closures are, of course, greatly facilitated by the temporarily increased capacity of the conduits, as explained earlier in the text.

At Englewood the stream-control problem is somewhat complex. The country is so flat that a closure entirely across the river valley

during one low-flow season is not to be thought of. The alternative, therefore, lies in what amounts virtually to building the dam in sections. The first season a cross dam is built on the east bank of the river. This cross dam is nothing more or less than a short section of the main embankment built from toe to toe, to serve as a retaining wall for the end of the hydraulic fill. Where this end dam lies within the outer portions of the main embankment it is built up of porous material; where it crosses the middle portion of the main dam impervious material is used. Thus the composition of the main dam from end to end is not interfered with by the fact that the cross dam is interposed. The cross dam is carried up only fast enough to keep well clear of the hydraulic fill. Where within the outer portions of the main dam the material for the cross dam

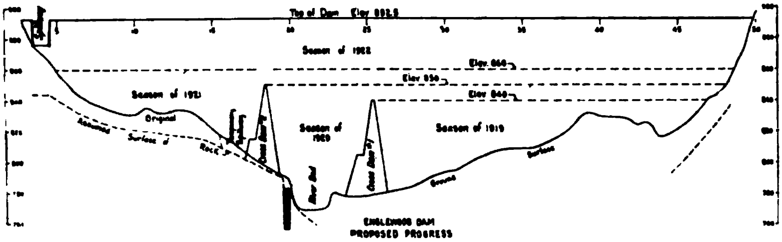


FIG. 17.

is pumped into place integral with the main hydraulic fill. The central portion is rolled in 6-in. layers, using a 12-ton steam roller.

With the cross dam in place to elevation 840, something over a million yards of hydraulic fill can be pumped without disturbing the river channel. This is a good season's work. In the meantime west of the river a temporary spillway, guarded on the east by a cross dam carried to elevation 850, will be constructed, and next April, with about eleven months of immunity from severe floods ahead, the river closure can be made and the hydraulic fill carried up to elevation 850. The third season sees a comparatively easy closure of the temporary spillway, and no further worry from flood flows, even should a repetition of the 1913 flood occur. The dam should be completed the fourth season. An inspection of Fig. 17 will make the foregoing program clear.

At all the dams the material for the hydraulic fill comes from the

river valley upstream and consists of a modified glacial drift. A slight exception to this occurs in the case at Taylorsville, where glacial till from the excavation for the spillway, so long as it lasts, is being pumped into the dam. The details of this process will be referred to more fully later.

In cross section the outer portions of the dam are composed of cobbles, gravel, and sand, and the central core of silt and clay. In the interests of safety the width of core in all the dams is confined to comparatively narrow limits. Such a procedure does not entail any particular hardship, inasmuch as the modified drift from the borrow pits contains roughly the desired proportion of clay. At Taylorsville, however, where the dam at present is being built of glacial till from the spillway excavation, the proportion of clay is so great as to necessitate some wasting from the pool. For simplicity the width of core has been arbitrarily taken as zero at the top of the dam, with slopes of 2 on 1. Thus the width at any elevation is equal to its distance down from the top. Expressed as a fraction of the width of dam the core as placed would amount to about one sixth. No particular justification can be advanced for adopting precisely this ratio, excepting to say that in the minds of the engineers it represented a structure eminently stable against sloughing and at the same time one that contained sufficient core to be impervious against impounded water. Very conveniently the adopted proportion of core coincides with the " fines " in the material from the borrow pits. This may not be entirely a coincidence. Hydraulic fill is in progress at this writing (September 1) at Englewood, Taylorsville, Germantown, and Lockington dams. Huffman has a big railroad relocation problem on its hands, and will not be ready to pump dirt much before next year.

The Englewood borrow pit is located upstream from the dam, as will be seen in Fig. 18. The material is excavated by means of two 115-ton dragline excavators, one electric and the other steam, equipped with 85-ft. booms and 4½-yd. buckets. The draglines are ranged along the same track, one about 1 000 ft. in advance of the other. An interesting comparison is offered as to the relative merits of steam and electricity as power for machines of this type. With electricity at slightly less than 1.6 cents per kilowatt-hour, the steam dragline is somewhat more expensive. The latter is

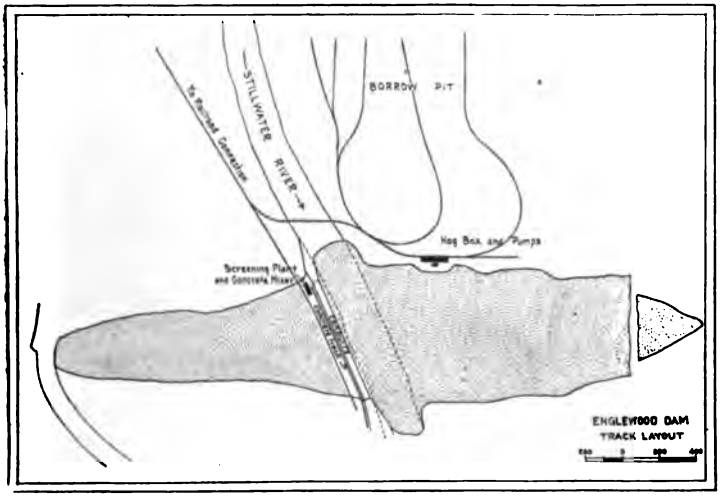


FIG. 18.

more rapid in operation, but the cost of coaling runs the unit cost above that of the machine using electrical power. The depth of face in the pit averages perhaps 15 ft., and the draglines load into standard-gage 12-yd. air dump-cars. Under these working conditions each machine can comfortably move from 150 to 180 cu. yd. per hour. A double-track system is arranged, with suitable crossovers, in such a manner that no interference occurs in the handling of trains.

There are four trains from the borrow pit containing seven cars each, which are handled by 40-ton locomotives. They climb a 2-per cent. compensated grade into a trestle 175 ft. long, paralleling and close to the upstream toe of the dam. From the trestle the cars dump into what has been given a name more practical than euphonious,— " the hog box." One standing at a point of vantage and watching the material going in and being devoured by the sluicing giants can readily see the application. The hog box is essentially a trough 150 ft. long and 27 ft. wide, ranged alongside the track from the borrow pit which, at this place, is carried on a pile trestle. The floor of the hog box is 13 ft. below the rail and cones at approximately 4 per cent. to an opening in the opposite side from the track. The opening discharges into revolving screens through

FIG. 19. ENGLEWOOD DAM.
Old river bed in foreground, Cross Dam and Hydraulic Fill in middle distance.

FIG. 20. ENGLEWOOD DAM, HOG BOX, AND PUMPING PLANT.

which the material passes to the sump. The sump is a concrete well, 8 ft. by 16 ft., divided by a partition into two chambers 8 ft. square. The floor is 16 ft. below the floor of the hog box.

The material as dumped from the trains into the hog box may be dry or wet, according to whether the draglines happen to be digging above or below ground-water level. As the material lies in the hog box, it is washed through the revolving screens into the sump by means of two hydraulic giants or monitors, one at each end of the hog box. Pressure for this sluicing water is furnished by two 10-in. centrifugal pumps, operating at a speed of 1140 r.p.m. and each driven by a 100 h.p. motor. The pressure is maintained at approximately 60 lb. and the jet is directed through a 3-in. nozzle.

The revolving screens are the product of several rejected schemes for eliminating the oversize rock from the material being fed to the dredge pumps. At first, sloping gratings of several types with square openings were tried. These were fairly satisfactory when the material was not coming too fast or when there was not too great a proportion of clay lumps. At such times the tendency was for the gratings to clog. Furthermore, each grating required the services of three men, clearing away the material. But the revolving screens seem to have effected a complete and simple solution of the rejection of oversize. The screens are cylindrical in shape, 4 ft. in diameter, have an effective screening length of about 9 ft. and are pierced with 6-in. circular holes in one case and 6½-in. holes in the other. The latter size is in the last screen installed and is an attempt to use the largest size openings without choking the dredge pumps. While the 6½-in. holes are satisfactory it is not known as yet whether or not this size can safely be increased. The screens pitch ½ in. to the foot. The first screen installed was given a speed of 14 r.p.m. but in its companion, installed later, the speed has been reduced to 9 r.p.m., and seems to give, if anything, more efficient service. Each screen is operated by a 7½-h.p. electric motor, belt connected, the reduction in speed being accomplished through a countershaft. From the screens the acceptable material drops directly into the sump, while the oversize rock goes out of the end into bottom-dump buckets which are hoisted out with a stiff-leg derrick and dumped into a standard car in which they are hauled away to the downstream slope of the dam. Not

only do the revolving screens serve to reject the oversize rock but, in addition, they fulfill another most important function. The tendency of the giants, even with the most skillful handling, is to wash the material into the sump in masses. Thus, one minute the dredge pumps would be handling comparatively clear water while the next they would be staggering to clear themselves of an overload. The action of the revolving screens, however, tends to rectify this irregular feed and to deliver the material to the suctions of the dredge pumps in a uniform flow. It is of the utmost importance that this delivery of the mud to the pumps be as uniform as possible. A neglect of this precaution has a most dire effect upon the output.

Directly beneath each screen is an inverted truncated pyramid with an opening 2 ft. square directly above the suction of the dredge pump. The object of this is to remix the fine material passing one end of the screen and the stones passing farther on. The suctions from the dredge pumps are inclined at an angle of 45 degrees from the vertical, and in order to lead the material to them along the easiest lines the floor is shaped as an inverted pyramid. It has been found that with a flat floor the mud has a tendency to pile up until at some point a great mass will slough off and bury the suction. Then comes the plug and a vexatious delay until the suction pipe is cleared.

The business end of the hydraulic-fill plant is the dredge pumps. At Englewood the present installation comprises two 15-in. centrifugal pumps, designed for 150-ft. head, operating at a maximum of 505 r.p.m. and each driven by a 500 h.p. slip-ring induction motor. These pumps are made of cast manganese steel, containing perhaps 5 or 6 per cent. of manganese (although the makers have not disclosed this). As yet this particular alloy seems to be by far the best fitted for standing the abrasive wear of sand and gravel. The shell of these pumps is from 2½ to 3 in. in thickness, depending upon the place. An item of the utmost importance is the design of the impeller, a matter which is complicated by the range of head against which the pump is called upon to operate. For instance, at Englewood the dredge pumps are working under heads which at the beginning are not more than 25 ft., but which are steadily increasing until a maximum of 150 ft. shall be reached, at

which point a booster pump will be inserted in the line. To compensate for this variation, different size runners are being tried, a smaller one for the lower heads and increasing in size as the heads shall increase. This arrangement is adapted to develop more fully the power of the motors. With the large runner against low heads a large percentage of horse power is wasted in overheating the grids. Diameters of runners of from 38 in. to 46 in. are being tried, but as yet it is too early to state results. The matter is, however, one of vital importance and will be carried along to definite conclusions.

The life of one of the manganese steel pumps as at present designed, pumping sand and gravel, is slightly less than 200 000 cu. yd. At Englewood the second pair of pumps is now in service, but the designers are making modifications in design for future deliveries, from which are expected better results. The impellers show wear at 50 000 cu. yd., but can be used, with doubtful efficiency, for perhaps 100 000 cu. yd. The consensus of opinion among those studying the operation of the pumps is that it does not pay to use equipment after it is badly worn. Economy is better served by scrapping the old shells and runners the moment they show signs of letting down. Inasmuch as the dredge pumps are the neck of the bottle, and the entire organization is succeeding in its purpose only to the extent that the pumps are functioning, it is obvious that they should operate at the highest pitch. To increase the life of the impellers, renewable shoes, for the wearing parts, are being tried.

The operation of the dredge pumps and monitor pumps requires about 31 c.f.s. of water. The location of the sump is 450 ft. from the river. Rather than pump the water this distance a 4-ft. corrugated-iron culvert was laid, through which the water flows by gravity. Near the sump a concrete well was built in the line to serve as a sump for the monitor pumps. Each of the two monitor pumps handles 2 000 gal. per min. The nominal capacity of each dredge pump is 7 000 gal. per min., which is the amount to be provided for, inasmuch as the discharge from the monitor pumps feeds into the sump.

The dredge pumps pick the material up from the sump and discharge it to the dam through 15-in. pipe. Where the pipe line runs

Fig. 21. Englewood Dam.
Hydraulic Fill, discharge from 15-in. dredge pipe.

Fig. 22. Englewood Dam.
Hydraulic Fill. "Drop-off" which takes place just inside central pool. Water in pool has been purposely lowered several feet.

up the side of the dam, and is therefore more or less permanent, the heaviest class of standard cast-iron flanged pipe is used. For the shore lines, however, where the pipes are changed for each run, a lighter pipe than the cast iron — one that can be handled with rapidity and ease — is required. For this purpose one of the large rolling mills is manufacturing a special welded manganese-steel pipe. This metal contains 0.50 to 0.60 per cent. carbon and 0.60 to 0.70 manganese, which limits are imposed by the rolling

FIG. 23. ENGLEWOOD DAM HYDRAULIC FILL.

process. The pipes are slip joint, i.e., have a slight bell on one end, and are held together by wire stretched over hook lugs. The thickness of shell is 11/64 in., the pipes are in 16-ft. lengths and weigh 28.83 lbs. per lin. ft. It is not known just what the life of these manganese-steel pipes is, for the very good reason that, to date, none has worn out. The greatest yardage that any of the pipes have passed to date is about 300 000. Riveted steel pipe, made from ordinary steel plate containing 0.10 to 0.20 carbon, proved very shortlived. Claim has been made that the manganese pipe will last ten to fifteen times as long as 0.15 carbon steel, and this may prove to be so. To insure an even wear around the circumference of the pipe, they are turned 120 degrees for each

new run. Observation shows that practically all of the solids flow within the lower third of the pipe, the upper two thirds being filled with water bearing only the lightest particles. Consequently, for a given run it is the lower portion of the pipe only which is subjected to any considerable wear. No difficulty is experienced in practice in doing this; one end of each pipe is numbered 1, 2, and 3, 120 degrees apart, and each time a line is relaid the pipes are revolved until the next number is uppermost.

The trick in pumping earth materials seems to lie in developing the consistent maximum capacity of the pumps and then feeding them uniformly to that capacity and no more. If the pumps are not receiving all the solids they can handle, money is being wasted. If, on the other hand, the pumps receive more than they can handle for any considerable time, a plug ensues and the entire pumping outfit spends many profane hours in clearing out the pipe,— not a pleasant or easy job at best. Of course, short overloads, if not too heavy, can be handled by the reserve power in the motor, but there is a limit to the length of time this reserve can be applied without injuring the motor, and also a limit to the amount this power can handle. The whole method involves a synchronizing of effort on the part of the monitor men and the pump runner. Either working without due regard to the other can waste efficiency or plug the system. If the pump man does not throw in an extra finger on the switchboard at exactly the same time that the monitor men are crowding the dirt, trouble ensues. At Englewood the first plan for coördinating the various operations consisted in establishing a control tower overlooking the hog box. Here were installed pressure and vacuum gages, electric-bell connections to pump man and monitor men, and connections with portable telephones at the ends of the pipe lines. By his electric-gong signals the foreman in the tower could direct operations,— signal the monitor men for more or less feed, as the case might be, or notify the pump man to increase his power. This was a big advance over anything tried before, but it had one weak spot,— the gages in practice did not always operate as swiftly or as surely as was desired. Sometimes the line would plug before the gages had given warning. But the difficulty has been solved by a very simple little device. The first sign of plugging in the pipe is manifested by a reduction of

velocity. This at once becomes apparent at the discharge from the pipe line by a slackening of the issuing stream. With this in mind the resident electrician rigged up a small attachment, consisting essentially of a steel clapper working on a hinge and forming contact at one end with an insulated wire running to the pumphouse, and at the other end with the jet from the pipe. The theory of the contrivance is that, with a full jet issuing from the pipe, the clapper is pushed against the contact points and the circuit is closed, but as the jet falls the contact breaks and the circuit is opened. Connected in the circuit are incandescent lamps, one at each monitor and one at each pump. Thus the monitor men and the pump man are constantly and instantly informed as to the condition of flow through the pipe, and can govern themselves accordingly. This simple device has resulted in a marked increase in the output and has borne a large share in the elimination of plugs.

In building the dam the pipes are ranged along the outer portion of the fill. As the material builds up, pipes are added, a 16-ft. length at a time, until the end of the run is completed. The line is then taken apart and a fresh start made, each run being 4 ft. higher than the previous one. Upon issuing from the pipe the coarser material tends to settle first, leaving the finer to be borne by the flowing water toward the central pool. On reaching the edge of the standing water, or slightly farther, depending upon the velocity, all coarse particles are immediately precipitated on a slope of about 1 to 1. Beyond this, nothing is carried but silt and sand. It will be seen, therefore, that the width of core is dependent upon the width of pool, provided, of course, that the material being pumped contains a sufficient percentage of " fines " to make a core of the desired width. If more than this occur, the excess clay must be wasted with the outflow from the pool.

In advance of the pipe line, to prevent a portion of the discharge from flowing down the slope of the dam, a levee is thrown up. At Englewood this is done by means of 35-ton steam dragline excavators, mounted upon caterpillar tractors, one operating just in advance of each pipe line.

The slope of the fill from the pipe line toward the pool is dependent upon the coarseness of the material and the percentage of solids in the discharging stream. For the Englewood material

this slope ran uniformly at approximately 6 per cent. for several months. During August, however, with an increased output, the slope has jumped up to about 7.75 per cent. A small amount of the water entering the pool seeps out through the gravel, appearing as small springs along the toes of the dam. The greater portion, however, must be led away in some form of wasteway. The method in use at Englewood is to dig a ditch about 8 ft. deep at one end of the pool, following the contour of the hillside. In this ditch a small earth dam is built through which are laid some old 20-in. dredge pipe. A wooden paddle serves as a gate for each pipe. Each spillway, progressing up the hillside, serves two runs, or 8 ft. in elevation of the pool.

As previously stated, the material in the outer portions of the dam is composed of cobbles from 6-in. diameter down to gravel and sand. At the " drop off," just inside the shore line of the pool, the grading changes to sand, quickly diminishing in size to silt and clay. An analysis of the core material, made by the Bureau of Soils at Washington, showed the following gradation:

Material.	Sieve.	Per Cent.
Fine gravel	2 to 1 mm.	0
Coarse sand	1 to 0.5 mm.	0.4
Medium sand	0.5 to 0.25 mm.	0.3
Fine sand	0.25 to 0.1 mm.	4.6
Very fine sand	0.1 to 0.05 mm.	19.6
Silt	0.05 to 0.005 mm.	52.7
Clay	0.005 to 0 mm.	22.6

Studies are being made, as the dam progresses, of the behavior of the core. It is known that it is becoming stiff at the lower elevations. A 1½-in. diameter pole shoved into the core meets sensible resistance at about 15 ft. The stiffening increases until at 25 or 30 ft. a man's weight will force the pole no farther. It is the intention to test the rate of stiffening in the core by noting the penetration of a 6-in. cast-iron ball. By this means a direct comparison can be had between the cores at the five Conservancy dams. Furthermore, this ball method was in use at the Calaveras Dam for the Spring Valley Water Company in California, and comparisons in penetration can be had with that dam. It is also the intention to insert in the core a number of pressure-recording

devices, developed by the Engineer of Tests, Bureau of Public Roads, Washington, for the purpose of measuring pressures in semi-fluid masses.

At the time the pumping plant was laid out, very little authentic data was available in reference to friction head in dredge pipe. It was thought that, with velocities of 12 ft. per sec., the loss of head would be about 4 ft. in 100 ft. In the clayey glacial till, such as is being pumped at Taylorsville, this is approximately true, but in the gritty sands and gravels at Englewood and Germantown, using velocities of 12 ft. per sec. or upward, it is found that the friction head is unexpectedly large, amounting to as much as 8 ft. per 100 ft. Such a condition throws a heavy penalty upon length of discharge line, and accordingly, at Englewood, studies are being made to abandon the present sump late this season and to use, progressively, three other sumps so located as to reduce both static and friction head to the least amount compatible with securing a satisfactory railroad grade from the borrow pit.

A matter entering vitally into the rate of progress of the hydraulic fill is the per cent. of solids in the water handled by the dredge pumps. At times clear water is being pumped; at others as much as 15 or 20 per cent. of solids is carried for short periods. The present average is probably from 6 to 10 per cent. Obviously, the higher the percentage the lower the unit cost, and studies are being made along these lines to find out just what can be handled. In the first place, there is vast room for improvement in the sumps. A sump is now being designed at Englewood from which much is expected. The principle being followed is to drop the material passing the revolving screens into the path of the water flowing to the suction of the pump and to fashion the entrance to the suction into a bellmouth to reduce the loss of head at entrance. But it is one thing to get the material into the pump and another to pass it through a long discharge line without plugging the latter. This feature is engaging the attention of the engineering force, and studies are under way looking to some form of spiral or rifling device which will keep in suspension the solids in the discharge pipe and offset the tendency to settle in the bottom of the pipe.

The monthly progress at Englewood, working two 15-in. dredge pumps, two shifts of ten hours each, has averaged 100 000 cu. yd.

Some minor changes in the screens and sump have lately served to increase that figure so that at present (September 1) each pump is delivering consistently 150 cu. yd. per hour, or a total for the two of 6 000 cu. yd. per day. The total amount placed to date aggregates approximately 650 000 cu. yd.

The hydraulic fill at the other dams of the Conservancy District is following so closely the methods in use at Englewood that only

FIG. 24. TAYLORSVILLE DAM.
Hydraulic Giant operating in Borrow Pit. Also Ground Sluice and Pumping Plant.

the essential differences will be noted. At Germantown the material to be pumped, the location of the borrow pit, and the general arrangement differ in no essential from Englewood. The dredge pump motors are 350 h.p. instead of 500 h.p., but this is on account of the lower head against which they will be called upon to operate.

At Taylorsville, however, the problem at present is somewhat different. As previously stated, this dam requires an excavation of something like a half million cubic yards of glacial till overlying ledge rock for the spillway. This till is high in clay, containing perhaps 50 per cent. The logical thing was to use the excavated

material for the construction of the dam, and the easiest way, considering that a hydraulic-fill dam was to be built, was to pump it into place. Accordingly, a pumping plant consisting of four 6-in. pumps, operated by 75 h.p. motors, was installed at a convenient place near the river. From here water is pumped through 15-in. spiral-riveted pipe to the excavation at 130-lb. pressure, and played upon the face of the pit by means of a hydraulic giant fitted with a 3-in. nozzle. More water is needed to convey the material than to break it down, consequently an 18-in. wood-stave line is run to the top of the face under sufficient pressure only to flow freely. Water for this line is furnished by one 12-in. pump with 150 h.p. direct-connected motor. The high-pressure nozzle handles 6.4 c.f.s., while through the low-pressure pipe 12 c.f.s. are carried. The sluiced material flows by gravity down a rough channel into a sump, from which it is pumped, in a manner similar to that at Englewood, into the dam.

The method of handling the levee ahead of the discharge pipe differs materially at Taylorsville from the dragline scheme described for Englewood. At Taylorsville the pipe, as it comes on to the dam, is separated by a Y-branch into two discharge lines. The end pipe of the line nearest the slope is slotted in the bottom in such a manner that the greater portion of the solids runs out, building up a windrow beneath the pipe. A few laborers handle this material into the levee. As each length of pipe is filled up the discharge is deflected at the Y into the line nearer the center of the dam, and flows through that line until an extra length of pipe has been inserted and the " window " pipe again attached. While this method seems on the face of it to involve less expenditure than that in use at Englewood, it is not applicable for the latter dam, owing to the much greater output there.

But one pump is operating at Taylorsville and working one shift only. The reason for this seeming lack of haste is that they are not ready to begin building the dam in earnest at this time. The hydraulic fill is simply the logical way to handle the earth excavation, and, in turn, the earth excavation is well ahead of the rock excavation, which latter is the key to the spillway construction and river diversion.

The dredge pump at Taylorsville is cast iron. At first, 34-in.

FIG. 25. LOCKINGTON DAM.
Hydraulic Giant working in Borrow Pit.

FIG. 26. LOCKINGTON DAM.
Hydraulic Fill; spillway walls in background.

cast-iron impellers were used in this pump, but they handled only from 6 000 to 10 000 cu. yd. These were replaced by 39-in. cast-iron impellers, which handled from 17 000 to 22 000 cu. yd. Manganese steel impellers, 34 in. in diameter, fitted with 36-in. shoes, were then substituted, and have handled to date 60 000 cu. yd. of material without showing undue wear. The original cast-iron pump shell is still in service.

The pumping at Taylorsville has averaged about 120 to 130 cu. yd. per hour with the one pump. To date, approximately 150 000 cu. yd. have been placed. As nearly as can be determined the percentage of solids in the mixture being pumped to the dam averages about 6.

The arrangement of the pumping plant at Lockington is somewhat similar to that at Taylorsville, although for an entirely different reason. There is plenty of suitable earth material well up on the hillside, favorably located for placing into the dam. Furthermore, the old Miami and Erie Canal, a relic of seventy years ago, passes at one end of the dam at a high elevation. This portion of the canal can easily be adapted for a water supply. Taking advantage of these favorable circumstances, a pumping plant, consisting of two 8-in. centrifugal pumps direct-connected to 100 h.p. motors, was located at a high elevation, receiving water from the canal through a flume, and serving a hydraulic giant in the borrow pit at 60-lb. pressure. This giant breaks down the face of the pit and washes the material down a ground sluice into a sump. Here it is picked up by a dredge pump and forced through a 12-in. line into the dam. As yet the hydraulic fill at Lockington is only started, and beyond a successful beginning little has been accomplished.

At the Huffman Dam an extensive scheme of railroad relocation has placed the hydraulic-fill operations farther down on the program than at any of the other dams. It is expected that pumping will begin in the early spring of next year.

The whole subject of hydraulic transportation of earth materials and the adaptation of this method to the building of dams is fraught with the greatest possibilities. We know that under favorable conditions the cost is low. We know also that hydraulic fill, with the right materials, makes the best earth dam obtainable.

But there are many little tricks in the placing of the material that we have yet to learn. We in the Conservancy work are constantly striving for knowledge along these lines, and our efforts are not going unrewarded. Our successes and our failures will at all times be cheerfully contributed to the engineering profession.

TABLE 1.

DIMENSIONS OF DAMS AND APPURTENANCES.

	Germantown Dam.	Englewood Dam.	Lockington Dam.	Taylorsville Dam.	Huffman Dam.
Drainage areas above dam, sq. miles	270	651	255	1 133	671
Maximum height above valley floor	100	110.5	69	67	65
Average elevation bed of river	723	770	876	759	777
Average elevation valley floor	730	782	885	770	785
Elevation of spillway crest	815	876	938	818	835
Elevation of top of dam	830	892.5	954	837	850
Maximum elevation of water surface for a flood like 1913	805	862	936	815	830
Area submerged in a flood like 1913, acres	2 950	6 350	3 600	9 650	7 300
Maximum amount of water stored in a flood like 1913, acre-feet	73 000	209 000	63 000	152 000	124 000
Maximum average depth of water in reservoir in a flood like 1913, feet	24.8	32.9	17.4	15.7	17.1
Length of crest of dam, feet	1 210	*4 716	*6 400	*2 980	*3 340
Thickness of dam at average elevation of valley floor, feet	650	739	410	390	380
Length of outlet conduit, feet	546	709	45	40	40
Number of conduits	2	2	2	4	3
Total sectional area of outlet conduits, square feet	182	217	158	1 116	705
Maximum discharge of conduits in 1913 flood, second-feet	9 340	11 000	8 630	51 300	32 600
Length of spillway crest, feet	55	100	72	132	100
Vertical diameter of conduits (temporary), feet	22 ft. 10 in.	22 ft. 6 in.	....	....	....
Vertical diameter of conduits (permanent), feet	9 ft. 1 in.	10 ft. $5\frac{3}{8}$ in.	9 ft. 2 in.	19 ft. 2 in.	16 ft. 4 in.
Maximum width of conduits	13 ft.	13 ft.	9 ft.	15 ft.	15 ft.
Yardage of earth in dams	790 000	3 550 000	1 032 000	1 131 000	1 547 000
Yardage of concrete in dams and appurtenances	20 000	38 000	38 000	47 000	40 000

* Including spillway crest.

PUBLIC CONTROL OVER NEW STREETS IN RELATION TO EXTENSION OF WATER MAINS.

BY BERTRAM BREWER, ASSISTANT ENGINEER, MASS. STATE DEPARTMENT OF HEALTH.

[*September Convention, 1919.*]

The interesting discussion at the March meeting of this year on the subject of financing the extensions of water mains, especially with reference to the possibility of special assessments on the abutters, suggested to the writer another problem connected with this particular branch of water-works activities. As some of us have reason to know, neither the possession of the money nor satisfactory means for procuring it necessarily secures a proper street to build in. Both suitable conditions and a suitable location may be lacking. Very likely the street lines are not so marked on the ground as to make it possible to properly locate the new pipe line and the new surface fixtures. The few marks on the ground showing the direction and boundaries of the street may be inaccurate and of a very temporary nature, so that, in the absence of proper plans, the street lines are certain soon to become involved in dispute, if they do not disappear altogether.

More often still, the street grade is established only by the surface of the muddy subsoil remaining after the loam has been partly scraped off under the direction of the exploiter who has developed this part of the municipal plan. It is obvious that the utter neglect to fix any kind of a suitable grade on paper and construct to it on the ground is a most important factor in making it impossible to locate the water mains or fixtures at a grade that will insure economy and permanency of construction.

These and similar questions as to the wisdom and practicability of the investment in new water mains have no doubt occurred over and over again in the practice of every man in the operating end of the water-works business. While it is often very difficult to determine whether the public's money ought to be spent in laying water mains in these doubtful street developments, the question

has a larger aspect in that it has to do with the orderly and reasonable development of the whole municipality — the town or city plan. It seems to the writer that the official in charge of the water department can exercise an exceedingly important influence in actually making operative the town or city plan because it is usually he who, by placing water pipe in a new street, first gives public sanction to its layout.

As has been intimated, the most common case that comes up for consideration is that of the land speculator who, if he is of the irresponsible kind, furnishes " a piece of this earth " or a " house site " for an enormous price, but on the instalment plan. He hypnotizes the ignorant public into buying bog holes, or ledges, or what not, only that he may sell as much land as possible, not to the particular advantage either to the purchaser or to the municipality but rather to himself. The writer had occasion once to expostulate with a speculator of this type. After pointing out some of the more obvious defects in his layout and suggesting co-operation on the part of the city authorities for the purpose of securing needed correction, or, if need be, wise and intelligent revision, he was met with the statement that this particular operator " was only a photographer, and knew or cared nothing about plans; he was there to sell land." The net result to the municipality of these sales is that the people build houses and move into the new neighborhood, unthinkingly relying upon the authorities at whatever cost to help them out of a dilemma that is to a great extent of their own making.

As every municipality has suffered more or less in this way, and as very few persons really know what is being done to meet the situation, we believe it is appropriate at this time to spend a few moments in a discussion as to what has been done and what may still be done to remedy the evil.

The initial control of new street development, so far as such control has been exercised, has, in Massachusetts, been delegated to an official body called the Board of Survey, a name that was adopted by the city of Boston in a law passed by the General Court in 1891, Chapter 323, when a Board of Survey was established for that city under the able leadership of ex-Mayor Nathan Matthews. The provisions contained in this law were immediately

put into effect, and, as is well known, streets in a large section of Boston have been laid out on paper by the Board and many miles of streets have been approved under this and subsequent acts.

Briefly stated, the Boston law provided that either through its own initiative or by petition of those developing land, all prospective streets must be given official sanction. Following is a condensed statement of some of the permanent interests of the whole community which are covered by this and later Board-of-Survey laws:

1st. A plan must be permanently filed with the public records sufficiently accurate and complete so that the exact boundaries of the street can be easily reproduced at any time.

2d. This official plan must show a final and reasonable street grade, also capable of reproduction at any time.

3d. Due attention must be given to good connections with existing highways as well as to an intelligent provision for future thoroughfares, all to be secured at a minimum of cost consistent with the conservation of the natural advantages of the entire district for home sites, factory sites, public uses or otherwise, as the case may be.

4th. The development must be such as will provide a good system of sewerage and drainage for the district to be laid out as well as suitable connections with the systems in the contiguous territory.

5th. The new layout must accord with a reasonable development of the water-works system with due regard to cost, accessibility, and circulation.

This last provision appeals to every water-works man, and suggests two questions appropriate to the hour. The first query is as to how such a control can be enforced; in other words, and speaking colloquially, how can teeth be put into such a law; while the second has reference to the application to your own city or town, — Has such an oversight of street development been established there, and, if not, how can its beneficent effects be secured?

The answer to the question as to how private development can be and has been in many instances controlled in Massachusetts

is that, up to within a year or two, the only method of enforcement possible under board-of-survey laws was to refuse public service in any private street not officially passed upon by the proper authorities. In this connection it is almost superfluous to emphasize again the fact before this organization that water pipes are usually among the first, if not the first, public utility installed.

Perhaps the best way to answer this query, and to suggest an answer to the question as to how the beneficent results of this law can be secured in any municipality, is to give a brief history of the board-of-survey legislation.

Attention is first called, however, to a particular provision in the Boston law of 1891 which was expected to furnish a more potent means of enforcement than that of refusal of public-service works in an unauthorized street. Section 9 of that law attempted to prevent building within the boundaries of a street approved by the Board of Survey or at a grade other than one that would accord with the grade shown on the official plans. This particular provision, however, was tried out in the courts and declared unconstitutional in that it took away certain individual rights without adequate compensation. We shall have more to say about this provision later.

As might be expected, the Boston law was soon discovered by several Massachusetts towns and after adaptation to the town form of government, board-of-survey laws were enacted for several of them, notably, Arlington in 1897, Revere in 1900, Watertown in 1900, and Belmont in 1903. The demands for these special laws became so numerous that a general law was passed in 1907 (Chapter 191), providing for a board of survey in any town that, by vote of its inhabitants, chose to accept it. This law is very similar to those already passed, and depends for its enforcement likewise upon the same provision that no water mains or other public works shall be placed in any private street not approved by the Board of Survey.

In 1909 the writer, after consultation and with the help of several legal and engineering friends, secured the passage of a special board-of-survey act for the city of Waltham, also to a great extent adapted from previous laws but modified to conform to the requirements and form of government of the average city.

This law provided that the city engineer should, by the virtue of his office, act as clerk of the board, and while it gave him no judicial authority it made him the executive officer of the board and furnished him an opportunity to accomplish much good at little expense.

This act, which was followed by several special acts for a number of cities in Massachusetts, was finally somewhat amended in 1916 and passed as a general law subject to adoption by any city in the Commonwealth.

As might be expected, these laws, while they have accomplished much good, have not done everything it was hoped for. Recalcitrant real estate sharks have snapped their fingers in the face of boards of survey and gone on with their nefarious work. It has been and is a difficult thing, but, nevertheless, an essential one, to educate the public to an appreciation of the importance of finding out whether a proposed street has been officially approved before buying land abutting on it. As a certain mayor of Philadelphia has said, "The people have not yet learned to think clearly and become sufficiently proud of their right to rule." But we know of one city where a real estate dealer of the type frequently described in this paper actually shook the dust of that place off his shoes when he found that there was a Board of Survey there, and if you will visit a recent development in that same city you will find a big sign conspicuously placed, advertising land for sale, displaying the magic words, — "These streets approved by the Board of Survey."

Certain well-meaning but misguided reformers of the class who see no way either of recognizing well-tried and experienced officials or of backing up or encouraging the men holding office, or, if need be, procuring better ones, but who are always scheming to create a new commission or a new form of government to further their so-called reforms, at one time threatened the successful operation of this law for cities by attempting to wipe out the boards of survey and to put this authority in the hands of planning boards. This would have practically divorced the constituted authorities from the charge of work which is legitimately their particular specialty. The attack was repulsed and the law still stands.

The friends of the Massachusetts board-of-survey laws, on the other hand, have constantly had it in mind to improve them. In 1917, Chapter 185, they were strengthened by adding the provision that any plan of land showing proposed streets or ways in a community where a board of survey has been established must be officially approved by the local board of survey before it can be filed at the registry of deeds. As few banks will take a mortgage nowadays unless suitable plans are filed at the registry of deeds, this law furnishes an important additional check.

Reverting now to the attempts to actually prohibit building within the lines of an approved street, attention is called to a law passed in 1918, Chapter 110. This law applies to towns only, and appears to give to the proper authorities the right to formally establish the lines of board-of-survey streets without compelling their immediate construction. It prohibits new building within the lines of such streets, and provides for the payment of damages. It seems to the writer that its provisions and application are somewhat indefinite, and might involve a town in two damage payments, — one when the board-of-survey street lines were established by the town and another when the time came for constructing the street.

Mayor Peters of Boston attempted this year to secure a control which would prevent unauthorized building in Boston. This bill, House 568, prohibited the sale of land included in a board-of-survey street, and also forbade the erection of a building on any land not abutting on a public or private street or way without the written approval of the Board, and, in case of violation, allowed the city to take possession of land so sold, or of buildings erected without this permission, subject to a proper damage; but betterment assessments could be levied in connection with the establishing of the highway. This bill was adversely reported, owing to a misunderstanding both as to its scope and the necessity for it. It was poorly presented to the committee. The chairman of the committee told the writer recently that if some such provision had been incorporated in a bill which would be applicable to any city in the state where the board-of-survey law had been adopted, he would have been very much interested to secure its passage.

We would suggest that while it is a fact that thus far the government of this country has been wisely built upon the rights of each individual to hold and transmit private property, it would seem that the roads are in a peculiar class. It is certain that just as soon as a street is laid out on paper and lots are sold, abutting upon it, certain public works, especially the water supply, are demanded and the street is started on a course which insures its becoming in time practically the property of the public. Is it not then perfectly reasonable for that public to have some choice as to what kind of property is to come into its possession? It would seem that this peculiarity, ultimate and certain public ownership, puts the new street in a class by itself when it comes to public control over its alignment and grade.

It must not be forgotten, however, that all suggestions as to more public control are more or less speculative at the present time, and we are now working under existing laws, such as they are. It follows, then, that such men as make up this Association, men who know just how things have to be accomplished and what it means to actually put plans into effect, must be depended upon to make the board-of-survey laws a success.

Before concluding this paper mention ought to be made of a phase of the question of extension of water mains which is important above all others. It ought to be noted here parenthetically, even though it may to some extent weaken the force of the argument for board-of-survey streets. The financial question is an important one; permanency and good city planning are likewise of great moment; but we do not need to be reminded that no other question can equal in importance that of the public health. A community cannot afford long to have a disease-producing neighborhood in its midst. No one knows how soon it may become a center of infection for the whole town, and the economic loss in lowered health and morale may be such as to make the cost of almost any physical improvement, or of any extension of the public service, seem a comparatively insignificant item.

Nevertheless, selfish speculators must be controlled, and that they can be controlled to a great extent in the way pointed out in this paper has been demonstrated over and over again; and, after all, the fact that it is likely to become a health question makes

it all the more important that initial control shall be established. Of course, not all real estate operators are irresponsible, and both seller and buyer are usually glad to avail themselves of public control when such control is exercised by a far-sighted and intelligent official who has made a special technical study. We believe, then, that a scheme of control is in the process of making, a control that will ultimately eliminate the uncertainties that confront the water-works officials when they undertake to extend water-works pipe lines into private and unaccepted streets. Can your help be enlisted?

Discussion.

Mr. Frank J. Gifford.* I should like to say, for Mr. Brewer's encouragement, that the superintendent of the water works in Dedham and the superintendent of the water works in Plymouth are working along these lines. Plymouth and Dedham both have boards of survey; the power is vested in the selectmen. We could not be selectmen but had ourselves elected to the planning board, so that we could follow those plans along. Perhaps we are dishonest. We hope all water-works superintendents in Massachusetts will follow along those same lines, and then we will accomplish what Mr. Brewer seeks.

Mr. David A. Heffernan.† I will say for the town of Milton that we were fortunate enough to fall into line in regard to private ways, and we adopted in 1913 the Board of Survey Act. We had there, of course, a great many demands on private ways, and we had to turn them to one side in regard to the grades for layouts, and so forth.

Now, we adopted this Act in 1913, but gave the abutters on private ways a little leeway. That is, if the layout were approved and plotted before 1913, if the conditions of the grade were such that a fair return could be secured — that is, five per cent. of the outlay — we would consider putting in the pipes, and we had done so up to that time. But since then the speculators have come into different sections of the town and opened up streets, and the

* Superintendent Water Works, Dedham, Mass.
† Superintendent Water Works, Milton, Mass.

conditions were such when the application was made, and we have referred them to the Board of Survey Act.

I think this Act is one of the greatest things for water works or any public utility that has been produced. I hope that every superintendent of every city or town that comes under this Act will have it accepted.

MR. J. M. DIVEN.* I think that this matter should be brought to the attention of the city authorities other than the water companies. To use the expression of the street, it is up to the water-works superintendents who have heard this paper and who will have the opportunity to read it later, to see that it is brought to the attention of the authorities in the cities and towns in which they live; and not only to the authorities, but to the public of the city or town through the local newspapers.

It would be a very good idea if reprints of this paper could be distributed to the members, to be brought to the attention of the newspapers and the city authorities.

MR. T. J. CARMODY.† Mr. President, I am somewhat interested in this matter. I came all the way from Holyoke to be enlightened on just exactly what this gentleman has read here to-day.

The city of Holyoke adopted this bill and then established a 5 to 7 per cent. grade. Plans have to be filed with the city engineer, and the water board gets its instructions through the City Engineering Department to lay the mains. We have laid mains that cover now about twenty feet of the street surface.

Holyoke works under a charter — possibly there is no other city works under charter. It is owned by the city but absolutely in the control of three commissioners. In looking around I suspect that all are paid that come here. Now, the three commissioners in Holyoke are unpaid. They have absolute control of the revenues of the department. They collect the money, they disburse it, they invest the funds of the department.

The problem which we have been up against is this: The land sharks came to Holyoke and opened up great portions of undeveloped land, ran a plow through and called it a street, sold lots upon those so-called streets, and asked the Water De-

* Superintendent Water Works, Troy, N. Y.

† Water Commissioner, Holyoke, Mass.

partment to lay mains, which they did in a good many cases. On account of the high cost of everything, the department now needs additional funds, so that the question arose how to get additional funds; whether or not we were going to raise the water rates, which are very low at present, or devise some other scheme. So the commissioners passed a vote that we charge for any new extension of main a dollar a running foot. Now, we thought that the thing was quite perfect, but we found that it was not.

In laying an extension, one man had a lot 60 ft. long, another a lot 75 ft. frontage, another 80 ft., and a fourth, 100. We found the man that wanted it extended to his lot, not to go beyond that lot, and the entrance was to the center of his house, which of course usually was in the center of the lot. He said, " Why, you haven't put in 75 ft. of main; you have only put in 30 or 40 ft.; I am not going to pay for the 75 ft. which you have not put in." Of course the main stopped where the entrance was; there was nothing built beyond it. So that we ran up against that snag, and came here to-day thinking that we would get a little enlightenment from you.

Now we have solved the problem. We found that we extended mains into streets where there was a house built and nothing had been built upon that street for a number of years. The main is already laid in that street. The question came before us, How are we going to charge the builder of a house upon that street now that the main is already in? The superintendent and our engineer differ upon that point. We have referred that matter to the board, as to whether or not we ought to have a fixed sum, requiring every person making application for a service to pay some fixed sum, and allowing the dollar a foot to stand. They presented a report jointly signed, but differed on the details. The engineer says that we ought not to make the charge where the main is already in the street; the superintendent says that we ought to. And they present tables showing that we would get less revenue charging a dollar a foot than we would in making a fixed sum. That is, that we would have more service applications on undeveloped land where mains already exist that would bring in revenue of from $2 000 to $4 000; whereas if we applied the dollar-a-foot plan we would only get $200 or $300.

The estimated value is about $2 000 000, and the net debt is only $250 000. We are selling water low, — $6.40, or something around that, for a family. The meter rate is 5.1 cents a thousand gallons. Very little of the water is metered. We do not wish to advance the rates, but want to get after the land sharks. The people who purchase those lots are trying now to compel the land sharks to pay the city. We have got to do something, but do not know what, owing to the question of the difference between our engineer and the superintendent.

If the gentleman has looked into that matter at all I should like to ask him if he can give us any enlightenment upon that.

Mr. Brewer. I do not think I can throw any light on that matter just now, Mr. President.

Mr. W. A. MacKenzie.* I think both of these questions are very important. In Wallingford we make no extension unless it pays eight per cent. on the investment. Also, there is to be no main extension unless the developers of the property properly grade the streets previous to the pipe being laid. The department had to adopt this rule as the municipal authorities — although this is a municipal plant — let the land developers come in and begin to sell lots on these streets that they simply blocked out without paying any attention to the contour of the ground, in regard to the levels of sewers or later developments; and it has become so now that if the question comes up in regard to these streets, the municipal authorities will ask, "Have you got a water pipe in these streets?" and we say, "Yes," but it has got to be moved if that street is accepted. So that the department itself had to bring about the ruling to prevent all of these past troubles of being obliged to relay mains and to get mains into streets where the revenue would not be sufficient to warrant an extension. It has grown to be a very important question. Only recently we started in on new grades on a certain street and the house development and construction, the sidewalks and curbs, had followed the original contours of the ground regardless of this development. And, in order to get things straightened out, these blocks had to be lowered, and the municipality has now to pay damages of over $3 000. It is something we have perhaps

* Superintendent Water Works and City Engineer, Wallingford, Conn.

some responsibility for, in not compelling the original developers, some fifteen or twenty years ago, to follow some established grade.

It seems to me as though this is a very important question at present, to save the municipalities large expenditures in damages in future years, and also to prevent land sharks from opening up new tracts and simply plotting them out to their own greatest advantage in selling the lots. I think that the municipality should ask the engineers or developers to conform somewhat to the contours so as to prevent undue future development for the laying of sewers and grading of streets. In the past they have in many cases simply let them block it out regardless of the hills or hollows which may exist in the development. The development would be along better lines and present a better appearance, the street would make better building lots, if they paid a little more attention in the development to the blocking out of the lots so as to follow the contour of the ground somewhat.

Mr. George A. Stacy.* I think this paper touches a vital point of almost every working engineer in every growing town or city. When we first started, with the rush the work called for, the improvement of the streets was not given particular attention. The street was laid out, an estimate of cost was asked for, and the price of construction based on that.

Now, we found that new streets were laid out and the grade established by the men who sold the land for house lots. The width of the street was not definitely stated, or was not controlled by the city, and the consequence was that when an estimate was called for we had to make it as we found conditions, and then after awhile, when there was some building there, they wanted the street built. It was not a very good street that the promoter built, as a general thing. You would be hub deep in mud in the spring, and it was filled with old rubbish. When the city took it up, the first thing we had to do was to set the grade, and we found we had buried the pipe 10 to 12 ft. in some places and left it bare in others. So that the time came when we passed ordinances that no water pipes should be laid in private ways until the grade had been established by the city engineers and the grading and filling paid for by the outsiders. We thought we had it all right —

* Superintendent Water Works, Marlboro, Mass.

and it looked that way. But here is a man who laid out a street, and the city engineer established the grade; they asked us then to make an estimate for laying the pipe. They complied with the requirements creating the revenue, and then some of them wanted to do this cutting and filling themselves, and asked the superintendent if he would not put in the pipe and trust to their honesty to do the grading. If the cut was not large the request was granted, and the pipe laid. The result was that they found it pretty hard work to get the pipe in in cold weather so as to protect it from the frost.

Another thing has now come up. One of our large manufacturers, an owner of a large lot of real estate, opens up a new tract of land called "Chestnut Hill." He laid out and built fair streets with proper width, and asked for the water pipes to be laid in those streets. He wanted to build houses there. The scheme was, instead of starting at the commencement of the street, he put one house about in the middle, and built another one at the end. His guaranty was 10 per cent. for ten years on the total estimated cost for laying the pipe. Well, as he was a very progressive man and had built up a large section of the city through his business enterprise, the city felt bound to go ahead with this, and as he laid out a large tract there and went to considerable expense the city laid the pipe, which probably would not pay more than one per cent. from the amount of buildings that were there at that time. That was all very well if this man had lived, and we could not tell that he was going to die before this thing had developed. The consequence was that this large tract of land, with a mile of pipe or more laid in it, only had about fifteen or twenty houses on it. Instead of collecting a revenue of 10 per cent. for ten years, we have to fall back on what we can get out of the people that live there. It was all laid out into house lots. There is a problem which it is pretty hard to solve. Here was a man who had done so much for the city, he wanted this work done and was willing to do the reasonable thing, as he thought, of guaranteeing 10 per cent. for ten years, by which time he thought the place would be all built up.

Our experience before that had been that this arrangement had proved satisfactory on practically all our streets, but those de-

velopments were not as extensive as this one. The revenue required was wiped out before the time elapsed, so that we got more than the required revenue from the regular returns from services.

But then in came the land sharks and touched our city a little bit. We had one property where we laid out the streets. They wanted to know how soon we could get a water pipe in. I looked at it and said about three months if I had plenty of steam drills to blow out this rock. It started off with a good solid ledge right from the main street. Some people were foolish enough to buy house lots on that land. That is the condition to-day. We have recently had a development start there. It is hard work, it seems, to make the public see that it takes time and money to put water pipe and sewers through, and they expect when they build the house that you are going to rush in and give them the water, no matter what the revenue is or what the cost is going to be.

The result has been that we have a large amount of pipe that is paying very little money, and are still working under this same rule.

Now, the sewer was the same way. When the legislature consolidated the sewer and the water departments, I introduced an order to have the same rule apply to the sewer as applied to the water pipe, — that none should be laid in a private way until the grade was established by the city engineer.

To show how little attention the city government sometimes pays to the recommendations of the water superintendent, — although they are willing to pay a first-class salary, they are not willing to listen to good advice, — there has never been any action taken, and quite recently in a sewer extension we were obliged to build, in order to get this sewer in, at additional expense which should properly be applied to the man promoting the scheme.

So we are all up against this same problem. It is hard work to devise a scheme, because when you say you want the city to take hold of this matter and make the ruling, which is evidently for the benefit of the whole community in the long run, they want to do it the easiest way and let the poor city stand the brunt of it

afterwards and do the work twice. I think most of us have been up against this same problem of seeing the unnecessary work done, when, if proper rules were put in effect, the promoters of this property would educate the public in buying the land to see that a provision was made that the water and sewer should be introduced, and we would soon be over this trouble. It is a hard thing to do. When a man buys, or twenty-five or thirty people buy house lots scattered around a proposed extension, and invest their money there to make homes for themselves, and then ask you for the water supply that won't probably pay more than two or three per cent. on the cost, it seems hard for the city to do it, and it seems hard to refuse these people who, insanely or ignorantly, have invested their money, their hard-earned money, in establishing homes for themselves, and then want the utilities, the necessities, that they never thought of before. That is a pretty hard problem, and it seems pretty hard work to impress upon the public the necessity of making some provision for educating the people up to demand these necessities. It is like the man going to work and building his cellar without making any allowance for the entry of sewer or water pipes, gas, and so on, and then later on it is necessary to tear down his wall. That does not pertain to this question at all, but it shows how careless the people are, who buy these properties, about other things connected with it. It seems hard to compel them to pay anything extra for it, but at the same time they have their money invested there and they can't live without the water, and the question is, What are you going to do about it? The superintendent is placed between the two millstones. He feels in one way that the people are entitled to the service, while his interest on the other side compels him to say it should not be done unless a proper amount of money will be received to pay a reasonable return upon the amount paid for extending the main and the sewer.

It is a very vital question for some of us; it touches the growth of the city, the home-builder, and the citizens in general.

Mr. M. N. Baker.* We should bear in mind in speaking of this subject that 25 to 40 per cent. of the area of our cities is occupied by streets and other public places; that in the past the

* Associate Editor, *Engineering News Record.*

real estate developer for his own selfish ends, as has been so well pointed out in the paper, controlled the layout of streets to a very large extent, almost wholly in many cities, instead of the matter being under the control of the city for the benefit of the people for all time. The interest of the real estate operator is momentary compared with the scores or hundreds of years that the people must suffer for the mistakes that are made.

This subject that has been presented in this paper, it seems to me, is really only one element in the broader subject of city planning as a whole. The people of our cities are interested not merely in street grades and the layouts of individual streets; they are interested in the entire street plan of the city, and in order to have these things right we must have bodies in control of city planning which will take all of these things into account.

Now, it appears from the paper and from what information I have from other sources that in Massachusetts the boards of survey, having control of just a portion of the elements that enter into city planning, got a foothold before we knew much about city planning in this country. And it also appears, although it is not brought out in the paper, that the city planning boards, which I understand are compulsory in all cities in Massachusetts and may be adopted by towns of 10 000 population and upwards, have really very little more than advisory powers. These boards of survey seem to have considerably more power, — some real authority.

Now, whether it be the board of survey or whether it be the planning commission, the whole matter, all the elements that enter into city development, should be vested in a well constituted board which shall take all into account. In the municipal program framed by the National Municipal League — which is essentially a model city charter with supporting documents — there is a very brief provision for the city planning board, which I had the opportunity to draft, and if I may be allowed to do so under the circumstances I would commend that section of the model city charter to those who are interested in this subject.

I would say, further, that these topics which have been up for consideration, as brought up in the paper and by a part of this discussion, — all of them that relate to city planning and that

relate to this very troublesome question of controlling streets and preventing real estate men from locating houses, as they will, right in the street that has been laid out, have been discussed at length from year to year in the city planning conferences which have been held for a number of years past. There is a vast amount of material bearing upon this subject to be found in the annual reports of those city planning conferences.

Mr. Beekman C. Little.* This paper has been very valuable, as well as the discussion which has followed it. But I think I may possibly throw a monkey-wrench into the machinery. It seems to be that a false note has been struck, at any rate to some slight extent, in the antagonism to the real estate man.

I think our city board of survey or city planning commission has a much better chance of getting along with the real estate man, instead of calling him a crook and a land shark, by asking his help or at least pretending to ask it. The real estate profession is an honorable profession; it is legally authorized; it is earning a living; the men in it are not all crooks and they are not all land sharks, and if it was not for the real estate man I believe our cities would not progress nearly as fast or as well as they do. I do not believe that Rochester has better real estate men than any place else, but they certainly are a good lot of men, — a great many of them, — and they are not any worse, certainly, than the average lot of men in other lines of business. I think you will get a great deal of help from the real estate men, and that they will be very glad of your help.

I think in the paper it was suggested that advertising was a good thing for the real estate man, and they are very quick to take it up. In Rochester we not only ask them to submit their plans to us before they are approved, but we go further than that, perhaps, and help them plan out their layout. It seems to me that we should not go against them entirely.

Mr. Caleb M. Saville.† I think this is a most interesting subject. It is apparently vital just at the present time; nearly everybody is interested in it. And I should like to make a motion that a committee be designated by the President to consider,

* Superintendent Water Works, Rochester, N. Y.
† Chief Engineer, Water Department, Hartford, Conn.

collect data, and report with recommendations on the matter of assessments of the cost of main pipe extensions, and the relation of new street layout in connection therewith, this report to be submitted not later than the next annual convention.

(The motion was seconded.)

MR. FRANCIS F. LONGLEY.* I guess the members of the Association know well enough I am not a real estate man, but I have something I want to say in line with what the gentleman from Rochester has just said.

I have a feeling that a great deal can come from coöperation rather than from indiscriminate condemnation of the real estate men. There is no doubt in the world but that the real estate men in the end do a great deal in the development of cities. But I have in mind another class of technical assistants that can also be brought into this campaign. More or less has been said this morning in the way of criticism of both the seller of land and the builder of the house, placing some of the responsibility and blame for illogical developments on both.

Where does the architect come in on this? Oftentimes the architect is utterly neglectful of the trouble that he is getting his client into. I won't say that he is always neglectful, because a great number of architects are very considerate and careful in their arrangements for water pipes and drainage; but I know from experience that it sometimes happens, or it often happens, that the architect could save trouble for his client and save trouble and expense for the city if he would do what he should do as a technical and professional man in this direction.

Effective action along any line of this sort can more often be secured by coöperation rather than by condemnation, and it seems to me that in proposing a motion of this sort, such as Mr. Saville has proposed, for the consideration of this question, it would be well to include therein a proposal for the consideration also of coöperation that might be secured both on the part of the real estate men and of the architectural profession, in order to well round out the question.

MR. FRANK J. GIFFORD. I think that the architects are not considered in these developments which are the chief offenders.

* Consulting Engineer, New York.

I find in most cases of land development there are no architects employed. The man who buys the lot builds the house, or the contractor builds a bunch of houses, and the chief offenders are not on the tracts where architects are employed, but the houses are built on cheap tracts of land and the owners engage no architects.

MR. LONGLEY. I still believe that motion could be made more comprehensive.

MR. J. F. SULLIVAN.* Inasmuch as this is a very interesting subject and the discussion has not been completed on it, I move that this matter of the resolution be laid on the table until the discussion of Mr. Brewer's paper is completed.

(The motion was seconded and carried.)

PRESIDENT KILLAM. The following motion is on the table: That a committee be appointed by the President to consider, collect data, and report with recommendations on the matter of assessment of the cost of making pipe extensions, and the relation of new street layouts in connection therewith, this report to be submitted not later than the next annual meeting.

On motion of Mr. S. H. MacKenzie, duly seconded, the motion was taken from the table for discussion.

MR. S. H. MACKENZIE. I agree that this is a very important matter, one which we have a great deal of difficulty with. We have had as much difficulty in regard to streets which are at present open and are considered public highways. I think if that had had proper consideration a great deal of expense and trouble which a good many of the water-works departments had during that very cold winter would have been overcome. Streets in which pipes were laid on which no grades had been established were later cut down and the pipes left at a very shallow depth. A new superintendent coming along, not knowing what had been done, would not have the pipes lowered. If proper grades had been previously adopted and the pipes laid to that, the expense of lowering the pipes would have been done away with.

Our department is run in practically the same way as the department in Holyoke, and when we are called upon to lay a pipe in a certain street and find that that has not been properly

* Superintendent Chicopee Water Department, Chicopee, Mass.

graded, we, at the present time, are unable to get a grade from our authorities. Although a great many of our streets have been used for years, they have neither a street line nor grade. There are two places that I have in mind. In a great many places there are no fences and no maps on file of the streets at all. It is difficult to know where to lay the pipe in regard to lines and grade.

Especially in the town of Southington we are up against it in getting the grades. I happen to be the engineer who makes the maps and grades, and when I ask for the grade it looks as if I was asking for a job. So that it makes it difficult for us to get what we should have. I have even gone so far as to recommend that the water department and the gas company apply to the town and signify their willingness to pay a portion of the expense if the town authorities will only establish lines and grades on all the streets, so that we can know where to lay our pipes. If that were taken up and a proper state law put through, we could then immediately tell those who make application for water that we cannot lay our pipes, according to law, until the proper grades and lines have been established, and it would do away with the petty jealousy which sometimes crops up in small places.

The law at the present time in regard to new streets is fairly good if the authorities would follow it out. Anybody who opens a new street is required to have the same approved and accepted by either the selectmen or the city authorities. But they are not always careful and do not always handle the matters as they ought to. For instance, last week I had an inquiry from a certain party in regard to a street, and I asked him if he had had it accepted. "Why," he said, "I have been to the selectmen and they asked me if the ground was level, and I told them, 'Yes,' and they said it was all right." I said, "Have you got a map to show where it is?" "Why, no," he said; "it is on that hill up there." Well, that is about all that he thought he had to do, and it was a wonder that he did not get the street accepted by simply filing a piece of paper. But it has so turned out that before it will be accepted he has got to have a proper profile made.

So that I would like to see incorporated in that motion something in regard to old or present streets, — something after the pattern of the Massachusetts law.

PRESIDENT KILLAM. If you will pardon me, I think that could be very properly considered under this motion that is pending. I should think that the members of the committee would take up all phases of the question without amending the motion.

MR. WALTER T. SCHWABE.* I should like to see the word "assessment" in the resolution changed. There are many privately owned companies in the Association, and in that case the word "assessment" does not apply. Ordinarily they do not have a great deal of difficulty in the method of making extensions for real estate projects, as they have to build up the community, and the future of the water company depends upon the growth of the community.

The gentleman from Holyoke the other day was in a quandary as to how to get sufficient capital to make the required extensions. Of course a guaranty from the promoter gets you nothing except a lot of trouble, but that can be handled by obliging the real estate promoter to pay for the extension and then returning the money to him as he sells the lots and the houses are built. Any works will know what they are operating for, how much they need for interest on the investment, depreciation, and taxes, and they can determine whether they want eight, ten, or twelve per cent. returns on the investment. They will know how much money they can spend for each house. If they can stand $100 for each house and the man wants an extension costing $500, he can pay $400 for that extension and have it returned to him at the rate of $100 for each house that is in the future put up. We do not have any difficulty in getting along with real estate promoters on that basis, as they realize that the mains are put in there to help them sell the land and the houses. The money is returned to the promoter as the building gets on.

It would be well if we had a standard method on which extensions were made, but I think that the word "assessment" in this resolution should be changed so as to include private companies.

PRESIDENT KILLAM. Are you ready for the question? Perhaps I had better read this again:

"That a committee be appointed by the President to consider,

* President and General Manager, Water Company, Thompsonville, Conn.

collect data, and report with recommendations on the matter of assessment of the cost of main pipe extensions, and the relation of new street layouts in connection therewith, this report to be submitted not later than the next annual convention."

(The motion was carried.)

MR. BREWER (*by letter*). The writer desires to thank those who participated in the discussion. He is entirely in accord with the suggestions of Mr. Baker, and believes that the provisions for city planning drafted by him in connection with the model city charter proposed by the National Municipal League show great care in their preparation and a lively appreciation of all the elements involved. The writer of the paper believes, however, that emphasis should be placed on the effective help that practical men in the operating end of the local government can accomplish in solving the problems under consideration. That is why the paper was written.

He does not believe that a city planning board, as it is constituted in most of the Massachusetts towns and cities, under existing laws, except in cases where it has an executive member who has an appropriation and a force of surveyors at his disposal and who will put plenty of his own time and ability into the work, will ever be able to accomplish much in the way of controlling street development. The executive officer in the smaller towns and cities is usually the town or city engineer who ought to have the requisite ability to grasp the problems involved and should know what he ought rightfully to have, and keep after it tactfully and persistently until he gets it. If he is the superintendent of water works, or can get the help of the superintendent of water works, it will go a long way toward success.

The idea of coöperation among all the persons representing the various interests involved, as expressed in the discussion, is more than an idea, it is an ideal, and one which must be continually before us.

SWIMMING POOL MANAGEMENT.

BY WILLIAM P. MASON, PROFESSOR OF CHEMISTRY, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N. Y.

[*September 30, 1919.*]

Of course a swimming pool should be constructed in a satisfactory manner from an engineering standpoint, and it is especially desirable that the means of getting the water out of the pool should be carefully looked into. Several pools that I have had more or less to do with have their outlets in the side. That is a very serious error. If there be any deposited matter in the pool that is to be gotten rid of it is practically impossible to draw such sediment through any side orifice without nearly emptying the pool. If the orifice be in the floor, then the material can be pushed on top of the outlet grating and a very few turns of the valve handle in the pipe leading to the sewer will dispose of the sediment without difficulty and with small loss of water. With a pool the size of ours at Troy, containing 100 000 gals., unnecessary loss of water quickly runs into money and attracts the attention of people who have to pay for it.

I have noticed that the side gutters are sometimes poorly designed. If they extend too far from the wall it is a very serious inconvenience; on the other hand, if they are covered by the overhang the swimmer cannot easily spit into them unless he is a dead shot, and in his efforts to do so he often misses entirely and the sputum gets into the pool, where it proves a most disgusting thing for a bather to swim up against.

"Fill and draw" pools are usually filled and emptied about once a week. This type is getting somewhat scarce, and water must be pretty cheap in order to allow of such a form of operation. More commonly the water is continually circulated as at the Rensselaer Polytechnic, is subjected to some system of improvement, and is replaced after long, stated intervals. At Rensselaer we retain

the same water for a year, making the change in August. That time is selected because the students are then away and we can run out the old water, look things over, and refill with less inconvenience. Throughout the year the same water is continually circulated by the pumps through the filters, of which we have four, each 4 ft. in diameter. Our rule is to chlorinate once a week with " chloride of lime." Where the same water passes constantly through filters using alum it is necessary to keep watch of the alkalinity and restore it at times with soda ash.

What is to be done in the way of protecting the pool by rules? It is easier to make than to enforce them, and at times some failures will occur, but on the whole they are not troublesome. So far as disease transmission is concerned, people who are suffering from anything very serious are not likely to ask admission to the pool, and if they do ask admission it is the watcher's business to keep them out. I believe that there is less trouble in the matter of damaging the pool from specific diseases than people imagine, due very largely to the fact that people who are suffering therefrom do not care about entering the bath, and certainly they do not care to be caught doing so. We do not ask that a man with a slight cold shall refrain from bathing. In some places they do ask that, but it is carrying the protection of the water pretty far. I have no doubt that a man with a mild cold can easily get by without being detected and get to the pool if he wants to go.

At what temperature is it best to keep the water? At Rensselaer we keep the pool at 76°, except on the occasion of a swimming match of some kind, and then we run it down to 72 merely to put a little " pep " into the men who are performing. Under ordinary conditions if one is going in simply for the pleasure of having a dip, or for learning how to swim, anything short of 74 or 76 makes it a rather strenuous undertaking. In the summer time a swim in the open is quite different, and one can stand cold water then very well, but with a pool under cover in the winter time, unless the water is up in the 70's a bath feels uncomfortably chilly. Of course a Turkish bath is a different proposition, — a cool pool is needed under those circumstances in order to start a reaction from the very high temperature to which the bather has been exposed.

High color or turbidity is unsightly, and masks such undesirable floating material as sputum, but beyond that either may be absolutely dangerous. I have in mind what happened at one of our large institutions not many years ago. The pool was very turbid, and on draining it a man who had been missing for some days was found at the bottom. Unless the bottom of a pool can be seen it is better not to use it. A prominent girls' school has recently closed its pool on account of the turbid character of the water. While it was still in use, whenever a group of girls went in the teacher had to keep watch all the time to see if somebody was missing. A turbid pool is very dangerous and should not be tolerated. A color or turbidity small enough to be possibly unobjectionable in a drinking glass might be sufficient to prevent the bottom of a pool being seen through a depth of 8 or 9 ft. Partly in this connection, it may be permitted to add, at one of our universities a fatality was occasioned by a student diving into an empty pool at night. Such an accident can of course be guarded against by suitable rules controlling admission.

To remove the sediment which collects at the bottom of the pool we use a sweep at Rensselaer, and push everything that settles on to the top of the outlet grating, whence it is flushed to the sewer by suddenly opening the valve. As I have already said, the grating must be on the bottom rather than on the side, to allow this to be done.

In pools used by women bathing suits are worn, usually colored ones, and the amount of fiber that comes off is vastly more than one would think, and it is most unsightly. I saw a device not very long since in Boston, designed to remove such material. It is best described as a modified carpet sweeper of the suction type, entirely similar to what is ordinarily used for cleaning floor rugs. The handle is about 1¼ in. in diameter, and of course it is hollow, and is attached to a suction motor by a hose. There is a brush at the bottom end, about 18 in. long and 6 or 8 in. wide, filled with stiff bristles set along a slot. Upon applying suction, the material goes out through the handle and is discharged into the side gutter.

Although chlorination and filtration are the usual means employed for keeping the pool water in proper condition, there are two other ways of securing water improvement — ultra-violet

light and ozone — which have been somewhat recently introduced. The University of Illinois formerly used chlorination, but they are now using ultra-violet light, and they speak well of it. As a device it is certainly very attractive in appearance. You may remember that the Athletic Club at 59th Street and Sixth Avenue, New York City, uses it successfully, although with what charge for upkeep I cannot say. The Board of Health of New York City has pretty thoroughly threshed out the question of ozone, and has reported favorably on it. The amount of money which is quoted in the Board of Health report is small enough, but the upkeep of an ozone plant is usually considerable. It is a fragile thing. And so is the ultra-violet light outfit a fragile thing. We have one in Troy used for other purposes, and we have found it to be pretty fragile in our experience.

At Rensselaer we attempt to keep our alum dose about one grain per gallon, but of course we do not hope to strike that amount accurately as we employ self-feeders. It is not as though we had a large plant where we could run in a well-controlled alum solution.

So far as chlorination is concerned, we use a very homely, but, we think, an efficient method of application; ordinary bleaching powder is mixed up with water into a cream and distributed directly by hand at the shallow end of the pool. In dose we use " bleach " enough to correspond to .6 of a part per million of chlorine, which is the amount legally adopted in California. At Yale they use .3; Northwestern, .6, the same as we do; and in some other instances the dose is as high as 1 part per million.

You probably know that there is an immense amount of objection on the part of some bathers to the dosing of a pool. We have had complaint, time after time, and it is usually based upon imagination. A bather cannot detect the presence of .6 of a part of chlorine per million. In practical tests we found that there was a suggestion of smell at 1½ parts chlorine per million, but no taste and no action on the eyes whatever. At 2½ parts per million of chlorine there was a faint smell, but there was no taste and there was no action on the eyes. When we ran up to 50 parts per million, of course we got a strong taste and we also got a strong smell, but did not notice any action on the eyes. The bathers have complained of dosing when no dose had been given. I

remember that, years ago, when we were about to turn on the alum at the new filter plant at Elmira the people tasted the alum four days before we put it in.

With reference to establishing a legal standard for the water of swimming pools, I know of only two states that have made the attempt, California and Florida. California has a pretty liberal standard. They attempt to keep the total count of bacteria below 1 000. At Rensselaer we do better than that. It may be rather more good luck than good management, but we have been running on an average of about 250.

So far as the presence of *coli* is concerned, we rarely get *coli*, as our .6 of a part per million of chlorine every week seems to control their growth. California allows one bacillus *coli communis* per cubic centimeter.

The preliminary showers should not be too cold and the soap used should be liquid. Many people dread a cold shower although they do not object to a cool plunge, consequently unless arrangements are made to take the chill off the shower water the actual washing accomplished by it will be rather sketchy.

Pools that are built in the open without protection from direct sunlight will probably be troubled with growths of algæ, especially if they be filled with ground water. Copper sulphate is the natural remedy in such a case, and the amount required, which is very minute, is best determined by trial. Considerable stress is sometimes laid upon the advantages of direct sunlight in those unusual cases of such indoor pools as possess it, but the gain is offset, at least in part, by liability to algæ growths. In such instances copper sulphate is again useful, but the need for complicated apparatus to administer the dose is unnecessary. Plants supplied with such dosing outfits seldom or never employ them.

Referring again to outdoor pools, it is unfortunate that some cities, even large ones, are not sufficiently careful to select suitable sites for their public baths. When a city goes so far as to fence off and equip some portion of a river or bay, setting aside the same as a public bathing place, the bathers have a right to assume that the site has been selected with care and that the water is hygienically safe, but sometimes the assumption is distinctly risky. In one instance a great metropolitan sewer emptied on the upstream

side of a public bath (now closed) and so near that when the sewage was colored by a red dye the bathers were startled by the bloodlike tint of the bath water.

It is vain to hope that high bacterial counts and the presence of "gas formers" can always be avoided. The human animal is not quite clean enough to insure that, but nevertheless it is entirely feasible so to run a public swimming pool as to keep its appearance attractive and its use within what may be termed "proper and reasonable risk."

Discussion.

Mr. Arthur L. Crane. Unfortunately, I am connected with the filtration business, but I speak as a member of the Association for Promoting Hygiene and Public Bathing.

I have made an investigation of about 500 pools, and the results of my investigation have been such that I should like to endorse all that Professor Mason has said, if a layman can endorse so eminent an authority.

In the matter of sterilization, I should like to make this point clear, — that as the result of my observation, and notwithstanding the fact that we, in company with all the filtration companies, supply a device for the feeding of hypochlorite of lime to the pool in connection with a filter on a circulating or so-called refiltration system, I have found that the results obtained by the primitive method described by Professor Mason of direct application are entirely superior to any method of feeding hypochlorite of lime to the water in its course of circulation, or any other method of sterilization. Ultra-violet rays, chlorine gas, or the hypochlorite of lime feeding device, are designed only to feed a given amount of sterilizing property to the water in its passage through the pipe. Therefore the sterilization takes place only in the small volume of water contained in the pipe or receptacle to which the hypochlorite of lime, the chlorine gas, or the ultra-violet rays are applied.

We therefore have a portion of a pipe, perhaps 2-in. pipe or 3-in. pipe, to which is applied the requisite dose of hypochlorite of lime or the requisite dose of chlorine gas, or its passage through the ultra-violet ray apparatus, where it receives the rays of light which

electrocute the germs which are for the moment in that 2-ft. run of water. That water is sterilized. It passes on into the pool, which is contaminated and impure. It was not impure when it was first filtered and passed into the pool, but since then the bodies of the bathers have added certain contamination. Then, as the impure water comes back into the sterilizing means, whatever it may be, whether it is my hypo device or the chlorine gas or the ultra-violet rays, the particular body of water passing through that machine is sterilized for the moment. But that sterilized quantity of water, usually in a 2- or 3-in. pipe, 2, 3, or 4 ft. long, passes on to the contaminated pool. It is therefore only a diluting process. You have a pool of 100 000 gal.; you have at the moment only a few gallons of water contained in the portion of the pipe or the contrivance to which the sterilization is applied, and that sterile water is introduced into the unsterile pool and is supposed to purify it. It only dilutes it.

I submit to you that the primitive method described by Dr. Mason is, as a result of my careful investigation of over 500 pools, the real thing. If you desire to purify the body of water, apply the required amount of hypochlorite of lime directly into the pool, and for a time at least you have approximately sterile water.

WATER SUPPLIES FOR THE AMERICAN EXPEDITIONARY FORCES.

BY COL. FRANCIS F. LONGLEY, CONSULTING ENGINEER, NEW YORK, N. Y.

[*October 1, 1919.*]

Mr. President and Gentlemen of the Association, — I have been home from Europe only about a month or six weeks, and am very glad indeed to meet my friends of the Association and tell them a little bit about the water-supply work "over there." I think that the work has been advertised very little, and I consider it a privilege to be able to tell you something about it.

I went over in August, 1917, at a time when the affairs of the American Expeditionary Forces were quite in their infancy, and when there was practically no work demanded in water-supply lines. I had been over there only a few days, though, when things began to develop, with demands for the increase or improvement of water supplies at ports, camps, hospitals, etc. For the first five or six months the work of the water-supply organization was confined entirely to work in the S.O.S., as it was afterwards called, or, in better-known terms, along the lines of communications.

The first work that was done was in connection with the improvement of water supply at some of the base ports, — Bordeaux and St. Nazaire especially, — and later some of the other ports, and numerous camps and hospital centers, and other centers of American activities. The work at the front — that is, the work for the combatant troops — did not start, of course, until the American forces were about to take over independent responsibility for a portion of the front, and that commenced in the early months of 1918.

During the fall of 1917 a number of the officers who had been sent over for water-supply work visited from time to time with the French and the British armies, especially at times when prepa-

ration was on for an offensive, in order that we might have the opportunity of observing what the French and the British were doing in preparation for water-supply work. And I might say that both the French and British authorities were extremely cordial and helpful, and gave us every facility for learning as much as we could and getting every possible benefit from their experience. Their experience had been a grilling one, and the help that we got in the beginning of our own problem was very substantial.

I feel that the matter of most general interest to the members of the Association is not so much the details of what was done in the field, because that, after all, was largely crude engineering; but, rather, the policies and the arguments relating to the policies, that were established for the prosecution of the water-supply work in France. The conditions, of course, were absolutely new; the whole problem had to be started and the organization and procedure built from the ground up.

Conditions in Former Wars.

One of the developments of the European War of 1915–18 has been the formation in the French and British armies of a branch of the Engineer Department known as the Water-Supply Service. A special organization for this purpose had not been known in any other war. In former wars, when armies were much smaller and more mobile and less constant in position, there was neither time nor serious occasion for the establishment of special water supplies for the troops. The conditions of this war, however, have been distinctly different from any former war, and the need for a provision for water supplies has arisen because of the relative immobility of the front, the concentrations of troops, and the higher standards in comfort for the troops that we are disposed to try to attain.

For its water, an army formerly lived upon the country. If the region was rich in water, all went well. If, on the contrary, the country was dry, the soldiers shared the lot of the inhabitants. If anybody gave any special thought to the question of water supply for the troops, it was the staff of the various units. Regions

without water were avoided as far as possible. Locations for camps and lines of march were selected where springs or good streams were convenient. Artillery and cavalry were camped along streams where animals could be watered. In brief, the army utilized the natural water resources of the country in a manner to involve the smallest possible amount of new work.

Conditions in Early Part of This War.

In this war, existing sources of water supply in the areas occupied by the armies have generally been inadequate for the concentrations of troops, and many of them have of course been destroyed or rendered useless. As the war progressed, the procuring of a suitable water supply became increasingly difficult, not only of potable water for men, but water for animals. As a result, both French and British armies found themselves under the necessity of establishing special services to take care of these requirements.

During the early part of this war, Allied troops were forced to face enemy troops in regions where water was very scarce. The troops after exhausting all local water resources would travel kilometers searching sometimes in vain for water for themselves and their animals. They would sometimes dig wells, but with no assurance of finding water. The troops located in the valleys might be able to find water, while those on the higher ground would not. All of these efforts, however, lacked coördination. The changes which followed in the course of battle further increased the difficulties. Those troops which through unusual ingenuity had sometimes managed to secure pumps for some of the shallow wells they had dug, might change their location and occupy a region entirely different in character, — a plateau perhaps, — and find there deep wells from which the pumps had been carefully removed by some one else. As in such cases it was impossible to use pumps except of a certain type, the troops could not utilize the material at their disposal, and were left without the water they were searching for.

The watering of horses was always a matter of the greatest importance and difficulty. When mounted troops are in the

proximity of an important river, the watering can sometimes be easily accomplished without special equipment. If only a small stream is available, large numbers of horses muddy the water seriously and make dangerous mires in the watering places, and the horses refuse to drink, or drink badly. It is possible to build small dams in such streams, thus forming basins in which the horses may drink with smaller danger of muddying the water. But there is always other work requiring time and personnel, and the tactical units hesitate to undertake work of this kind when they expect their stay to be of short duration. The condition of thirsty animals is more distressing to see than is the condition of thirsty men. Animals will lick the side of a water trough as though to quench their thirst, when water is not available. They lose their strength and can do only a fraction of their proper work when very thirsty. In the Champagne region, in the early part of the war, great numbers of animals are said to have died from thirst.

Early Steps by the French and the British.

In the French Army, the importance of adequate preparation for water supplies was not fully appreciated until the summer of 1915, when large numbers of troops were concentrated between the city of Rheims and the Argonne, with the purpose of undertaking certain offensive operations. A serious shortage in the water supply then developed, — so serious in fact that the abandonment of the contemplated offensive seemed to be necessary. In this emergency the first steps were taken toward the development of the French Service des Eaux which has operated effectively since that time.

I recall the French attitude at the time we were getting ready for the St. Mihiel offensive. Along about the middle of August, 1918, we got orders that preparation must be made in a very limited time for taking care of the concentration of troops that was to be made for the St. Mihiel offensive. They expected to concentrate some 500 000 or 600 000 men, and something approaching 200 000 animals, in a section of the front about 22 miles long, all north of what was called the Toul sector. It is a dry sector.

A large part of it lies in that portion of the front which was so frequently referred to in press dispatches as the Woevre. It is a broad, flat plain, largely of clay, in which there is little or no ground water until you penetrate to a great depth. There were dug wells in the region which afforded suitable supply for the use of a local community, — a few people and a few animals, perhaps. But to get in there with a hand pump and try to water horses out of them, — a single, small hand pump will often exhaust the capacity of a well like that in a few minutes, and the replenishment capacity is practically *nil*. When we started in on this job and told our French officers what we had ahead of us, that we had to provide water in that region for 600 000 troops and 180 000 or 190 000 horses, the answer of the French was, "*C'est impossible! C'est impossible! Il n'y a pas d'eau!*" "There is no water." And that was their point of view at the very outset. Well, we had to show them by the procedure we had developed that it could be done, and we proceeded to do it. But the French all the way through were very sparing in their provisions for water. In that respect the British differed in a very important degree from the French, and, likewise, we differed in an important degree from the French.

In the beginning, because of the limited material available, it was necessary to improvise much of the equipment required. The value of these first French emergency installations was found to be so great that their use had been continued, and until the termination of hostilities these water stations could be seen all along the western front covering a zone from just in rear of the front-line trenches to a depth of many miles toward the rear. Many of them have been under artillery fire, as their visibility and their importance often made them good targets, and many of them were damaged by shell fire over and over.

The reports of the operations of the French and British Water-Supply Services discuss water supply both for a stationary army and for an army on the move. These reports indicate that there should be a systematic series of water stations along the rear of such an army where horse-drawn water carts can be filled for use of the troops farther forward. A common distance for this series of stations has been from 6 to 10 kilometers behind the line.

If at a closer distance and not well concealed, it is sure to draw artillery fire; and if farther away, the haul for the carts becomes too great. Many water-supply developments have been made much closer to the front than that, even in or close to the front-line trenches, where time and conditions of concealment have permitted; but an exposed, unprotected water point could not long exist undamaged if located too near the front in an active area.

For a command advancing through country poor in water, both French and British have used automobile and horse-drawn tank wagons which followed up the troops and distributed the water to forward reservoirs or to the horse-drawn water carts, until the troops had again come to a standstill, enabling new water stations to be constructed to supply these forward areas.

These installations are always simple, being made up of such of the following elements as are necessary for the particular location: A small pump and motor, commonly driven by gasoline, if power is required; a simple wooden shack, housing the pumps and attendants; apparatus for the treatment of the water if needed and if conditions permit; a tank suitably located close to a highway; pipe lines as required; horse-watering troughs, and facilities for the drawing of water from the tank into water carts or other containers.

The French authorities have gone on the principle that all water supply should be considered as polluted. The colon bacillus is in fact present in a large proportion of all natural sources of supply in the army areas. Simple and effective methods have therefore been devised by the French Service des Eaux for the hypochlorite treatment of water, and a laboratory service under the Service de Santé determines the sanitary quality of the water from time to time and posts signs to indicate the quality.

The British authorities, too, have assumed that the health of the troops demanded the treatment of all water supplies unless proven safe. They have therefore made a practice of dosing water supplies with hypochlorite, but this has been done to a large extent by hand, at cart-filling stations, etc., and less use has in general been made of special or automatic devices for the applications of the dose than in the French service.

When the armies are at a standstill, as they were during the

two or three years of trench warfare on the western front, the work of the Water-Supply Service is not a complicated matter. It has consisted simply of a progressive development of water stations and their operation and maintenance. The difficulties of the Service arise during an offensive. Many water-supply facilities are destroyed, wells and springs are fouled or possibly even poisoned, and streams polluted.

I might say right here, though, that after a long and careful inquiry from many of the British and French water-supply authorities, an inquiry which I was delegated to make on an official basis, I could find no evidence of the actual poisoning of any water supply by the enemy with alkaloidal or other violent poisons. There are numerous cases of fouling of wells by dumping manure or dead animals into the wells, but that was a gross fouling that one could detect without the use of any laboratory apparatus. But, so far as the poisoning of wells in the commonly understood sense of the word, there are no authentic records of it, in spite of the fact that the newspapers have talked a lot about it.

The concentration of troops and of animals is large, and provision must be made for them, often under severe fire, within a few hours after they have moved over new territory. The wholesale transportation of water by automobile tank trucks is then brought into play, and as rapidly as possible well-digging crews, and crews for the installation of pumps, tanks, hypochlorite apparatus, horse troughs, etc., move forward as fast as possible to establish new water stations. Many such stations are erected and put in service in the course of a very few hours.

The chief of the Water-Supply Service of the Fourth French Army has stated the principle that an army never constitutes a mass sufficiently dense, and whatever idea one may have as to duration of the war, the immobility of the army will never be sufficiently prolonged to necessitate extensive developments of water, but that the greatest possible use must be made primarily of local resources.

The French developments indicate a closer adherence to this principle than do the British. The water points throughout the French Army areas are characterized by their large number and small size, their simplicity, and even their crudeness to some

extent. On the British front, on the contrary, the water developments have been fewer in number and of decidedly larger capacity and of greater extent. Developments having a capacity of a quarter to a half million gallons per day were not uncommon, and some of these had pipe lines running to total lengths of 15 to 20 miles, supplying numerous water points.

The difference in character of the water resources of the regions has undoubtedly had some influence on this. In the regions of the chalk of northern France in which the British armies were to a large extent located, wells could be bored very easily, and large yields secured, — yields running from 50 to 100 gal. per minute, or sometimes even more. Through the regions principally occupied by the French armies, on the contrary, conditions were much less favorable for securing good supplies from wells. Many wells were bored but with greater difficulty than in the chalk, and the yields of such wells probably averaged not more than one quarter the yield of the average wells in the chalk.

The first American contingent arriving in France after the United States entered the war, upon finding these conditions existing in the French and British armies, recommended for the American Army the establishment of a Water-Supply Service to carry on this work for the American Expeditionary Forces. Both the Medical Department and the Engineer Department were impressed with this need. A letter from the chief surgeon, American Expeditionary Forces, to the Commander-in-Chief, indicates the basis for this recommendation, and the chief engineer, American Expeditionary Forces, at about the same time, secured from the French authorities a statement prepared by the chief of the Service des Eaux, covering in general terms the principal requirements in personnel and material which the French service had found necessary for its work.

The War Department complied with these recommendations by authorizing a special service regiment, the 26th Engineers, for water-supply work, and by sending to France certain officers who had had sound experience in the various phases of this branch of engineering.

Early Water-Supply Activities in the American Expeditionary Forces.

The officers who were selected by the War Department for their water-supply experience, and sent to France in the midsummer of 1917, set themselves to the task of inquiring into and preparing to meet the water-supply needs of the American Expeditionary Forces. From an early date, it was clear that the water-supply activities of the American Expeditionary Forces fell naturally into three groups:

1. Water-supply work for the armies.
2. Water-supply work for the S.O.S.
3. Supply of materials for water-supply work both for armies and S.O.S.

It was obvious that during the early part of our service in France the water-supply work of the S.O.S. must constitute by far the larger volume of work. Active work in the field for the Water-Supply Service of the armies would commence only with the armies' assumption of responsibility. For a number of months, therefore, the water-supply work consisted of developments for hospitals, small towns, camps, depots, railways, port developments, etc.; and in this the entire water-supply force was engaged, including the first companies of the 26th Engineers, Army Water-Supply Regiment, after their arrival in France.

Activities of the Water-Supply Section, O.C.E.

Inquiries regarding water-supply programs of the allied armies were started at an early date, and the substance of these is outlined elsewhere in this report. The water-supply needs of the army were considered with great care, and the question of organization and of relations and duties of the army water-supply officers inquired into at length with numerous officers whose opinions were considered of important value in fixing such a policy. This resulted in the issue of Bulletin No. 55 and of General Orders 131, which have since formed the basis of procedure in army water-supply work.

A number of type plans were developed as a result of study of British and French water-supply facilities. An extensive inquiry was made into the question of water resources, especially ground water in the region commonly referred to as the American sector, which the American armies were expected to occupy. A comprehensive report was made upon this, parts of which have been of great use to the army Water-Supply Service in the field.

A consideration of the various reports and observations relating to the water-supply work of the allied armies resulted in the compilation of certain notes intended to comprise the fundamental principles which various water-supply developments for the army should follow.

The question of the kind and quantity of materials for the work was given constant study, and also the program that should be followed regarding production, shipment, storage, and issue of various kinds of materials. When depot shops were established, a certain amount of special manufacture was started of products which were otherwise difficult to procure, and for which the shops had the facilities. The laboratory and sanitary inspection branch was developed, demanding the constant attention of an assistant well versed in those phases of water-supply work, and involving close touch and clear understanding with the Medical Department. Considerable attention was given to the question of treating water supplies by means of liquid chlorine, and the specialized nature of the equipment required for the purpose necessitated bringing to France officers with special experience in this line.

The success of water-supply work in the army depends primarily upon the supply of proper material. The Water-Supply Section of the Office of Chief Engineer has worked in close touch with the Engineer Supplies Section on this matter, and it has been found highly desirable to maintain this relationship as closely as possible.

The supply of materials for water-supply work has involved in the past and will continue to involve many questions which are equally important to the work of the armies and of the rear. Materials for both of these services will come from a common stock in the depots. There were special forms of material which were used exclusively by one or the other; but a very large part of the stock was for common use.

In order that *both* services can be assured the materials they require in proper kind and quantity, and in order that one service shall not through design nor through inadvertence exhaust the supply of materials for which the other may have urgent need, and in general in order to guide certain phases of the problem of the supply of materials for water-supply work in a well-coördinated manner, the control of much of this can to good advantage be exercised by a single office. In France, this was done by the Office of the Water Supply Section, Chief Engineer's Office.

In developing an organization for activities of the magnitude of those in France, it was necessary to anticipate the need for water-supply officers who were to fill the most responsible positions in the field. With this in view, a number of experienced officers were brought over from the United States, held for a time in the water-supply office at General Headquarters, when they gradually worked into various permanent assignments in the field or office.

Outline of Field Responsibilities of Water-Supply Service.

The early field service of the water-supply organization practically began about February 1, 1918, with reconnaissances including the front of the French Eighth Army from the Moselle River westward to the Côtes-de-Meuse, and of the French Second Army from Côtes-de-Meuse, around the St. Mihiel salient, to Troyon, on the Meuse. During this period, American divisions were operating tactically under French Corps, and the French Army water services were carrying the water-supply responsibility.

The first responsibility of the American Water-Supply Service was that of the First U. S. Corps, which utilized first half and then all of Company B, 26th Engineers, on the Toul front, from the middle of May to the middle of June, 1918. This month, however, it was a matter of an American corps representing the American Expeditionary Forces doing water-supply work for divisions which, in turn, remained under the tactical control of French corps.

The same condition remained when the water-supply control was shifted from First U. S. Corps to First U. S. Army, about the middle of June, and extending to about the middle of July. During this period it even happened that once the American Water-Supply

Service had taken over the responsibility for the Toul front from the French Eighth Army the American service continued to function even though temporarily French divisions might be occupying part or all of the area.

One thing that appeared perfectly clear from the outset over there, was the importance of territorial continuity in the work. It was exceedingly important when one water-supply service took charge of the water-supply activities of any part of the combatant zone that they should continue in that capacity more or less indefinitely. Shifting of responsibility for a technical service like the water supply meant a lot of confusion. So, in this instance, as I say, once we had taken over the responsibility for the water supply for the Toul sector, before the Americans had complete control and responsibility for it, we continued handling the work there even though some of the time French divisions were moving in and out and occupying parts of the sector.

From the middle of July, 1918, to the middle of August, 1918, the Second U. S. Army took over the functions of the First U. S. Army in the Toul area, continuing to about the middle of August. About August 1, water-supply troops consisting of about 80 men of Company B, 26th Engineers, and all of Company A, 27th Engineers, took over partial water-supply responsibility in the divisional area of the neighborhood of Baccarat.

Likewise, about August 1, the First U. S. Army Water-Supply Service began to function in areas, in the Château-Thierry region occupied by American corps, operating tactically, however, under the French Sixth Army.

About the middle of August, the First and Second U. S. Armies headquarters organizations changed places, and the First U. S. Army began its St. Mihiel operation as covered in detail in the W.S.S. Report of that army. The Second U. S. Army headquarters organization, on the other hand, operating as the "Paris Group," became of decreasing importance in the Château-Thierry region until, about September 10, 1918, the last of Company D, 26th Engineers, was entrained and brought into the Argonne-Meuse area.

At about this same time, Second Army took over independent responsibility for a portion of the American front in the Toul sector,

and the available personnel, equipment, and material for army water-supply work was apportioned between the two armies in general accordance with the magnitude of the military operations which immediately confronted them.

Upon the creation of the Third Army to go forward to the Rhine after the signing of the armistice, two companies of army water-supply troops, with certain companies of other special service army engineer troops, were assigned to form a provisional regiment, and the water-supply work of the Third Army was handled by that organization for a time, until it became evident that its services were no longer necessary, and it was sent back with the balance of the organization to Bordeaux, and ultimately back to the United States.

Interest of Two Departments in This Work.

One of the first questions to loom up as important in the determination of a policy regarding the handling of water-supply work was as to the respective duties of the Engineer Department and the Medical Department in this matter, in which both departments are so vitally interested.

The Engineer Department has important responsibilities relating to the investigation, design, and construction of works for water supply, and other matters closely related thereto. For a decade or so past, water-supply engineering practice in the United States has given very complete consideration and attention to water-supply laboratory work in connection with the engineering phases of the work. The laboratory examination, sanitary inspection, and other phases that pertain primarily to the question of the quality of water supplies, are so intimately related to their design, construction, and operation, that it is practically impossible to separate them. On the other hand, the Medical Department has certain highly important responsibilities in connection with the quality of water as actually used by troops. All who have come in touch with the problem appreciate fully the fact that these two merge into one another.

The water for the supply of American troops will of necessity be taken from various sources, some of which may be, but many

of which will not be, safe to drink without treatment. Second only to the duty of supplying an adequate quantity of water at the time and place required, is the duty of supplying as good a quality as practicable. This is done by the water-supply organization where conditions justify, by disinfection treatment of the water by means of hypochlorite of lime or liquid chlorine, or by filtration where conditions indicate that to be possible and especially desirable.

The Medical Department, U. S. Army, has an established procedure for the treatment of water, consisting of the addition of a capsule of hypochlorite of lime to a measured quantity of water in the Lyster bag. This is or should be well known to every medical officer of a tactical unit.

Under the conditions of service in the field, it will in most cases be impossible to assure a supply of water to the troops which will be safe to use without further treatment beyond the water points. In the S.O.S., town water supplies will frequently be found which are safe to drink without treatment, and, after laboratory evidence has been secured to demonstrate this, there has at times been a disposition to authorize the use of such a supply without requiring treatment in the Lyster bag.

Universal Need for Treatment of Water.

As time has gone on, the impression has grown stronger and stronger in the minds both of the Medical Department and of the Water-Supply Service of the Engineer Department, that the rule should be laid down and insisted upon that all water should be treated with hypochlorite in the Lyster bag in the prescribed manner, regardless of the fact that it may in many cases be of good quality and safe for use by the troops. The fundamental reason for this is the necessity for water discipline. If troops get into the habit of drinking water without treatment, even though it may be known to be safe and pure, they will not appreciate the need for caution in this matter in other locations where the water may be unsafe to drink without treatment. They may either fail to get instructions, if instructions are given which indicate some new supply to be of inferior quality; or in spite of such instructions

they may fail to appreciate the possibilities of danger and drink freely of a dangerous water because they have not been in the habit of seeking water invariably from prescribed and treated supply.

If, on the other hand, there are no exceptions made to the rule that all waters be treated in the Lyster bag, there will be no interruption in the efforts of the authorities to require the use of water so treated, troops will be more likely to retain the habit of using water only from the Lyster bag, and it will be easier to assure a maintenance of discipline with respect to this matter because of the uniformity of the rule.

The question of water discipline is one which affects not only the soldier who goes looking for water to drink, but it affects also the soldier or officer who is charged with the responsibility for thus treating the water.

The concensus of opinion is that there should be only one exception to such a rule. If a considerable number of officers and soldiers are located more or less permanently in a town which has a public water supply of first-class quality, and are scattered through the community in such a way as to make the enforcement of the Lyster-bag rule impossible, it would be a proper procedure to announce that the water could be used without treatment. This might apply especially to important or permanent headquarters.

Wholesale Purification of Water where Possible.

The fact that a supply is to be treated in the Lyster bag before being used by troops should not cause the proper authorities to neglect the wholesale treatment of any water supply that is known or suspected to be polluted where the conditions justify such central treatment. The existence of a uniform regulation prescribing that all waters shall be treated before being used by troops, will not prevent a fairly large proportion of the troops using waters which either have not been treated at all or which may have been only imperfectly treated. Also, in many a town whose water supply is of doubtful quality, company kitchens and camps may be well provided with Lyster bags in which the treatment is regularly and effectively carried out, but soldiers who work elsewhere

in these towns cannot be expected to return to the location of these bags to get water to drink, but will drink from whatever source is convenient. In other words, the policy should be persisted in of treating at a central point all supplies that furnish water for a considerable number of troops, if the water is of doubtful quality and if the conditions justify the installation of apparatus.

Important Medical Department Responsibilities.

The responsibilities of the medical officer of a tactical unit include the treatment in the Lyster bag of all water supplied to his troops. This is a responsibility which cannot be taken by the water-supply organization. The medical officer with the tactical unit cannot and would not be relieved of it. Neither would he be relieved of the responsibility for assuring water of satisfactory quality in water carts, water tanks, or containers other than the Lyster bag, in the event of any conditions which permit the unit to use water in other ways than through this bag.

The control of this feature of alimentation has long been acknowledged as one of the Medical Department's most important functions. In the last analysis, they *cannot be* relieved of responsibility for this phase of the care of their troops. The medical officers of tactical units will in general feel safe only by satisfying *themselves* as to the quality of the water they are getting for their troops, and by seeing to its proper treatment through all the means at their command.

It is necessary to draw some dividing line between the responsibilities of the medical officers with troops and the water-supply organization. This division of responsibility must be so clear and simple that there will be no confusion in the minds of those whose duty it is to administer the details of the procedure.

Division of Responsibility.

Based upon the above premises, a logical division of these responsibilities would be as follows: the water-supply organization to make available adequate quantities of water at water points located as conveniently for the troops as the conditions

reasonably permit, and in as pure a state as practicable, using filtration or disinfection treatment, or both, as circumstances may justify; the medical officers attached to tactical units to attend to such subsequent disinfection treatment as the water may require, in the Lyster bags, in water wagons, tanks, or reservoirs from which water will be drawn by individual soldiers for direct consumption, etc.

This basis is the most logical one, since the responsibility of the water-supply organization in the construction of works and handling of the water terminates at the water points; whereas the responsibility for the transportation of the water from the water points to the final point of use, in cans, or pails, or water wagons, etc., rests upon the tactical units themselves.

The weight of these arguments was recognized in the discussions that took place between representatives of the two departments, and after concurrent approval by chief engineer and chief surgeon, American Expeditionary Forces, a general order was issued, G.O. 34, G.H.Q., 1918. This was later modified to make it clearer and more comprehensive, as G.O. 131, G.H.Q., 1918.

Numerous questions of procedure regarding points of mutual interest to the Engineer Department and the Medical Department were raised in the course of the discussions. The defining of responsibility in the general orders made it necessary to make the authority coincide, so that officers engaged in the discharge of Engineer Department functions would be assigned to and be responsible to that department. The occasion for specifying this arose out of the development in the Engineer Department, as a branch of the Water-Supply Service, of the laboratory and sanitary inspection branch. Much of its personnel was drawn from the Sanitary Corps of the Medical Department, and some of the water-supply laboratories were located in Medical Department laboratories, where otherwise there would have been a duplication of facilities.

This official designation of responsibility and authority should not interfere with the services of the officers of the laboratory branch, being of the maximum usefulness to the Medical Department as well as to the Engineer Department. With a full recognition that the water-supply problem is one which involves the

interests of both departments in a peculiar way, the duties of the laboratory branch are intended to include everything that either the Engineer Department or the Medical Department may want to cover in connection with questions relating to the quality of water supplies, and it must be fully and specifically provided that the information regarding the quality of water supplies shall be made fully available to the Medical Department.

The most careful consideration has been given to this rather mixed problem from the first, and the Medical Department freely consulted, with a view to arranging a procedure which would be understood and recognized as sound by both departments.

Establishment of Water-Supply Laboratories.

A laboratory branch was established with headquarters in Paris, where it has remained, owing to the connection which the officer selected to place in charge of the laboratory branch has had with certain work of the Interministerial Commission in French government laboratories. Upon the removal of headquarters, S.O.S., to Tours, a branch laboratory was established in Tours, to handle both sanitary and industrial analysis of water in that vicinity. Subsequently, water-supply laboratories were established either as parts of Medical Department laboratories or as independent laboratories under the Water-Supply Section at the following points: St. Nazaire, Bordeaux, La Rochelle, Dijon, Neufchâteau, Brest, Nevers, Le Mans, and London in the S.O.S., and also several movable laboratories were established in the army zone.

The personnel for this laboratory branch of the Water-Supply Section is made up partly from the Engineer Department and partly from the Sanitary Corps of the Medical Department, as both officers and soldiers having the requisite special training and experience are found in both departments.

The matter of reporting laboratory results was taken up very carefully in order to make it simple and systematic. Procedure was followed which resulted in complete records of all analyses being transmitted promptly from the engineer organization developing them to all the authorities who were vitally interested in the problem, — that is, the several medical department authori-

ties in positions of principal responsibility in the jurisdiction in question, — and also to certain engineering authorities within that jurisdiction. Maps were likewise prepared showing the location of all water points, the nature of those points, — that is, the facilities included in those water points, — and, where possible, some note regarding the quality and the capacity of the supply. These were printed in large numbers and circulated to all the authorities interested, especially to the responsible officers of tactical units coming into the area. For example, west of Verdun, between the Marne and the Argonne, maps were prepared from time to time as we occupied successive parts of the terrain. A map was prepared to be correct as of a certain day, was brought up to date during that day, and sent back to one of the army printing establishments, where the base prints already on hand were completed by the superimposing of the data on the revision of the water points, and a large number of up-to-date maps thus prepared were gotten back and distributed in the field within a remarkably short period, — a matter of only a few hours. So that new divisions or other units coming into the area for active operations within the next few days could have ready at hand in the most usable form all possible data regarding location, and capacity and condition of water-supply resources.

Standard Methods of Water Analysis.

Water-supply laboratory work in the United States is done on the basis of standard methods developed by a committee of the American Public Health Association. These standard methods were not considered suitable for the use of the American Expeditionary Forces, and the question of suitable methods was given lengthy consideration on the part of the various officers of the Water-Supply Section who had had extensive laboratory experience; on the part of the laboratory branch of the Medical Department; with due consideration for certain methods in current use by the French authorities of the Service de Santé; and also not less important, with proper consideration for reducing time and equipment to a minimum.

Field Laboratories.

Reference was made to the fact that the laboratories used were of two types, fixed and movable. A laboratory that can be easily transported from one scene of activity to another is especially valuable, even indispensable, in army water-supply work. This was foreseen when provision was being made for this work in Washington in the summer of 1917, and four special water-supply laboratories were designed and built, mounted on light motor trucks. They reached France in time to be used throughout our activities of the summer of 1918, and proved to be very useful.

Experience showed that the motor-truck feature of the laboratory was not of great importance, as a laboratory did not move often. In fact, in view of the serious shortage of motor transportation, it was a temptation to lift the body containing the laboratory complete, off the chassis, in order that the latter might be made use of. This was actually done, and the laboratories thus dismounted were used for long periods as fixed laboratories.

The Poisoning of Drinking Waters.

The poisoning of waters by the enemy upon returning from a region has always been looked upon as a possible menace to the safety of troops. In this war, preparation was made, both by the British and the French, to guard against this danger. Both of those services provided their units with suitable testing outfits, which have been used to some extent.

When the American Water-Supply Service made inquiries about this, with a view to determining their own program, no authenticated cases of the chemical poisoning of water supplies by the enemy could be found, in either the French or the British services. As a result of this, the practice of making routine toxicological examinations of newly acquired water supplies has been carried out only irregularly, and in some regions not at all.

The armies of each nation, however, are supplied with the apparatus and personnel necessary for carrying out these examinations, poison-test kits being placed in the hands of properly qualified medical officers. They should by all means be available,

but more as a preparedness measure against the possible future use of poisons by the enemy than because of any practical utility at the present time.

Owing to the difficulty of poisoning water supplies, on account of the added poison being washed out by the natural flow of water, the difficulty of collecting samples during the confusion of an advance and the difficulty of properly guarding a well from thirsty men while a toxicological examination is being made, the feeling has grown up that the toxicological examination of newly acquired water supplies will never become an important problem.

Need for a Recognized Policy and Procedure.

The prospect of a demand for water-supply work in the army zone, emphasized the importance of getting, at as early a date as possible, a clear decision of the question as to whether the Water-Supply Service should be an army service strictly, operating directly under the chief engineer, army, or whether it would be an army service only in name, but operated to all intents and purposes as a corps organization. It was believed, as a result of much discussion of this subject, that the most effective work could be done by the Water-Supply Service if it operated with a direct control from Army Headquarters. The French Service des Eaux operates in this way, and affords one of the best evidences we have of the propriety of this procedure.

It was assumed from the outset that the Water-Supply Service ought not to be attached to the division. The territorial jurisdiction of the division is very transitory. A division may be at one place only a few days. The corps is even less mobile than the division. It is, however, still mobile in the sense that its geographical boundaries may change, especially in connection with great activity. This may be accomplished in a manner different from the bodily movement of the division into or out of an area; perhaps by orders which alter the number of divisions in a given corps, or some other relatively simple procedure which has the effect of altering the territorial boundaries of its jurisdiction. If water-supply troops and water-supply officers belong to corps, there would then result a sudden change in jurisdiction which

could be accomplished only with difficulty and lost motion, in changing the control of work which pertains so distinctly to the area, rather than to the tactical unit. Such changes as this would be most likely to occur at times of great activity. Then, of all times, continuity of control is of dominating importance to maintain.

Further, it is recognized that in the development of water-supply work, one system may with advantage supply troops in two corps areas on opposite sides of the common boundary line between corps, due to topographical or geographical conditions. Pipe lines may cross these boundaries. One pumping station may serve points in two areas. An ample source may be available on one side of the boundary line, and nothing readily available on the other side. These conditions all point to the desirability of a control of water-supply work from Army Headquarters.

Need for Continuous Territorial Jurisdiction.

Water-supply work is dependent upon topography and other factors which tie it definitely to the ground. Divisions are mobile, and the tendency is to make them more mobile rather than less. The territorial jurisdiction of the divisional commanding officer and divisional chief engineer is transitory. In moving into a new area they are sure to be extremely busy with other functions which pertain practically entirely to tactical problems. Water-supply projects should be systematically looked out for by a responsible organization which has a geographical constancy. This development will be under way before a division comes in, continued during its presence, and completed often after the division has left a given area. The division furthermore has a right to expect work of this sort to be done for it by some other agency, and should not be burdened with any real responsibility for this development.

The only definite control which should be exercised by corps or divisions should be that which fundamentally belongs to them, as for example, police control, traffic control, and near the front, measures for safety.

An important factor in deciding this question was the fact that

the Service des Eaux of the French Army operates on the basis of control from headquarters army. The corps, in general, has no responsibility for water-supply work, except to indicate its needs to the Water-Supply Service, if not already foreseen.

Army Control, Bulletin 55.

This matter was finally covered by the issuance of Bulletin No. 55, G.H.Q., 1918, definitely placing the water-supply troops under the chief engineer, army, with a direct control over the water-supply work throughout the entire army area. Provision is made for assuring that the wishes of the corps or division engineers in water-supply matters be given the greatest possible consideration consistent with primary control from the Office of the Chief Engineer, Army. This was supplemented by a memorandum of instructions from the chief engineer, First Army, to the commanding officers of special engineer units, emphasizing the imperative need of keeping in constant touch with corps and division engineers in such a way as to assure the fullest possible compliance with their wishes.

Component Parts, Army Water-Supply Service.

The experience of several months' activities of the American Army in France has shown that an army Water-Supply Service should consist of the following:

1 regiment of army water-supply troops.
1 water-tank train, complete with personnel.
1 M.T.C. mobile repair unit, complete with personnel.
General engineer depot shop trains and trucks.
Additional labor troops.
Additional officers for staff and special duty.
Water-supply laboratory branch.

The combination of such labor troops as are required, with an engineer regiment having specialized training of personnel, makes for flexibility and efficiency. The water-tank train serves the vitallv important purpose of wholesale transportation of water in

situations that do not permit the prompt supply of water in any other manner.

It was by means of our water tanks, which at that time were organized and ready to do business, that we overcame the difficulties that our friend, the French liaison officer, feared when we started to get ready for the St. Mihiel offensive. When they said it was impossible we knew it was possible, because we had carrying capacity for some 60 000 gal. of water on wheels at one time. And we worked that hard; and this was the only means, by the way, which could have kept the armies supplied with water in the dry area. The improvement of the quality of the water, where conditions justify it, or at least the inspection of water supplies and their laboratory examination, and the spreading of helpful information regarding quality, is assured by the laboratory branch. The maintenance and repair of all motor-truck equipment, in prime condition for use at any time a period of activity of army is announced, can be accomplished by the presence of the M.T.C. mobile repair unit. The G.E.D. shop trucks assure independent ability to handle almost any of the varied kinds of mechanical work the water-supply service encounters in the field.

Regiment of Water-Supply Troops.

The regiment of army water-supply troops, the 26th Engineers, was organized at Camp Dix, made up to some extent of volunteers, and to some extent of men especially selected from the draft, for their knowledge and experience in water-supply work. They were brought together and given some preliminary training, which was of a purely military nature, in Camp Dix, before they went to France. An effort was made to select them carefully. There was a demand for these companies in France very early in the fall of 1917. When the first demand was made from France for some of these companies to go over and go to work, the companies had not yet been recruited up to their proper strength with special personnel, and the authorities simply threw into the organization such miscellaneous labor troops as they could find handy and sent the whole bunch over. As a result, the first two companies that came over were rather a poor assortment. I recall

when they landed at St. Nazaire there was more or less criticism on the part of the authorities who had first to handle them and to put them to work. Criticism, I mean, of the make-up of some of the companies. One point of the criticism turned upon the fact that they had among their number a dancing master, also a candy manufacturer, and they could not quite see what a water-supply organization needed of a dancing master and a candy manufacturer, — no more could I. That was corrected, however, later on.

The regiment had a normal strength of about 1 600 men, with something between 40 and 50 officers. The officers with few exceptions were men who had had considerable experience in water-supply work, and they were really the backbone of the water-supply service over there. Some were sent with the organization, and others as a result of requests for men specially qualified in water-supply work, and these made up the staff organizations to a large extent. I will not attempt to outline the details of specialized training, but you can naturally see that a considerable number of men competent to handle well-drilling apparatus were required, large numbers of men who were familiar with pipe work in all its phases, considerable numbers of carpenters and concrete workers, and so on. The classification would go through a fairly large range.

Just prior to the cessation of hostilities, when things had grown hot enough so that we were stretched to the limit of our capacity and ability with this limited number of specially trained men, we finally got an authorization through the War Department for the creation of a second water-supply regiment, the 228th Engineers. To go back to the early history of it, the first outline at the War Department in 1917 prepared for one such regiment for each army that was to be created. It provided the first regiment in connection with the plans for the First Army. The Second and the Third armies were created in the field, with very little preparatory work, and it seemed as though nobody in Washington took the initiative in organizing and sending over to France the special-service engineer troops which were required to build the complement of each army. That was true not only of the water-supply troops but of all the other special-service troops; and as a result we had to

take our water-supply regiment and the other troops that had learned something about water supply, divide them up, and scatter them all over France. While it was demoralizing to organization spirit, it greatly broadened the scope of our activities, and the service that could be done for the American Expeditionary Forces as a whole. It was very unsatisfactory from a management point of view, however. Owing to the cessation of hostilities and to the suspension of action regarding all further promotions and original appointments, the 228th Engineers was not organized.

Use of Tank Trains.

The water-tank trains are intended primarily for the wholesale distribution of water in areas not yet reached by the satisfactory development of water supplies, such for instance as an area taken by an army in an advance or an area held for a long period under shell fire which is severe enough to prevent the construction or the maintenance of water points.

The water-tank trains were a very important part of the outfit over there. Certain water-tank trains were ordered in this country back in 1917, but did not arrive in France until midsummer, or later than midsummer of 1918. Realizing how indispensable they would be when we came to field activities, we improvised certain water-tank trains for use in the St. Mihiel offensive, and between that time and the time the Argonne offensive commenced, some of our water-tank trains commenced to come in. So that from that time on we had an ample supply of tanks mounted on motor trucks. The water-tank trains as organized — not the improvised trains but the trains ordered from this country — consisted, if I remember rightly, of about 135 tanks mounted on motor trucks, and 14 mobile water-purification trucks, certain repair trucks, and certain other special transportation. Each train had a personnel, including the mechanics, chauffeurs, and others, amounting to about 500.

The special water-purification trucks were of the greatest use and greatest interest. We had over there a total of something like 40 of them, if I remember the figures rightly. With a few exceptions they consisted of a filter, a pump, and a liquid chlorine

machine, all mounted in compact form on a substantial motor truck, and having a delivery capacity of about 1 200 gal. an hour. They were extremely useful.

The French, as I intimated a while ago, had made no use whatever of surface waters. Their developments had been entirely from ground waters. If they could not find a spring or a well, or if they did not have time to dig or bore a well in order to develop a ground water supply, they merely said, "*Il n'y a pas d'eau!*" and that was the end of it. They were astonished when they heard that we contemplated the use of the muddy waters of some of the streams, — streams in which cavalry and artillery horses had trampled and stirred things up to a dreadful degree a mile or so above the point at which we proposed to take the water. But these special purification equipments could be wheeled up into place, a connection dropped overboard into the muddy streams, the equipment set going, and within a very short time it would be delivering a stream of water that was clear, clean, and pure, as determined by laboratory tests. There was a laboratory, incidentally, attached to each of these equipments. It was the saving of the situation, really, in both the St. Mihiel and the Argonne offensives.

The use of the water-tank trains involves filling points having a capacity great enough so that the tank trucks are not seriously delayed in filling. Only a few minutes should be occupied in filling each truck, and the pumping capacity, storage capacity, and piping must be so arranged as to permit this. These filling points must be located where they will be reasonably safe against enemy shell fire and gas, and yet as close as is reasonable to the front, and on or near the main routes the water-tank trains will follow going forward. Alternate filling points should be prepared as a reserve, as far as conditions permit, to be ready in case of interference with the use of the principal points. Routes must be selected leading forward into the areas to be supplied, and due consideration given, so far as limited choice will permit, to conditions of probable traffic congestion. Return routes must also be indicated for use until such time as forward filling points can be established. Reservoirs or tanks must be placed well forward in the regions to be supplied, into which the water can be emptied

from the tank trucks, and to which the nearby troops can come with their water carts, pails, etc., for filling. A schedule of the movement of the detachments of tank trucks should be studied and established. It is recognized at the outset that traffic congestion and other uncontrollable conditions are almost certain to make it impossible to adhere to any predetermined schedule. A systematic program is necessary, however, to assure the best results under the difficult conditions in the field and to aid in the transmittal of orders and information.

If the attempt is made to deliver water from the tank trucks directly to organization water carts, pails, etc., as a retail proposition, the work of the tank-truck detachments cannot be handled as expeditiously as the wholesale delivery to tanks or reservoirs. Furthermore, the obligation for getting water from some local point where it is made available in wholesale quantities rests usually upon the tactical units themselves. Nevertheless, under some conditions in the field it has been found desirable to use the tank-truck detachments as a means for the retail distribution of water, especially during periods of traffic congestion and troop confusion which frequently accompany an offensive movement.

Improvised Water-Tank Trucks.

When the First Army took the field for active operations, the equipment of the water-tank trains had not yet arrived in France. Water-tank trucks had to be obtained, however, and it was necessary to borrow some and to improvise others. A number of trucks were secured from the Quartermaster Corps, intended for hauling gasoline. For the rest, 5-ton trucks were mounted with closed steel tanks, giving a total capacity for each truck of about 1 000 gal.

During the St. Mihiel offensive the filling points were about 10 to 15 kilometers back of the line. A large part of the country covered by the offensive was very dry and devoid of natural water resources. There were practically no springs over a wide area. There were numerous dug wells, and these of course were used to the limit of their capacity; but a single hand pump was frequently enough to exhaust the storage in one of these wells, and the inflow

into the well thereafter was very slow. There were also a number of bored wells, some of which had been put down by the French military authorities. When equipped with suitable pumps, these could be made to give a certain yield — but it was small, running on the average only 10 to 20 gal. per minute. None of them near or beyond the enemy lines were provided with pumps at the time of the offensive, and they did not, therefore, constitute an available resource for some time after the offensive started.

Very promptly after the beginning of the advance, detachments of water-supply troops went forward, keeping as close to the advancing line as possible, and built canvas reservoirs or made other arrangements for containers in suitable locations. The improvised water-tank trains then carried water from the filling points farther back to these forward reservoirs, making trips as frequently as the traffic conditions would permit. As quickly as possible new filling points for the tank trucks were established in the new areas, in order to cut down the length of haul on congested roads.

The special water-purification trucks are not in general of adequate capacity for use as filling points for water-tank trucks, and for this use with the water-tank train they can be considered as valuable only in pressing emergencies. They were put to this use to very good advantage, however, during the St. Mihiel offensive.

In the activities west of Verdun, the water-tank trains were used extensively, and were indispensable in many parts of the region. In order to facilitate the prompt utilization of the detachments of tank trucks, the water-supply companies were very enterprising in the construction of forward reservoirs. The water-supply detachments, with horse-drawn vehicles carrying canvas and necessary tools for the quick construction of these reservoirs, were in some cases the first vehicles to go forward over the roads, following the advance of the infantry lines.

Motor Transport Corps. Mobile Repair Unit.

The quantity of motor-transport equipment belonging to each water-tank train and to the water-supply regiment in an army

justifies the presence of suitable means for maintenance and repair.

Each motor-transport corps mobile repair unit is stated to include the following equipment:

1 5-ton machine-shop truck, carrying a generator set with motor-driven screw-cutting engine, lathe, drills and grinders, hand and machine tools, welding, soldering, and blacksmith outfits, and full equipment of ordinary and special automobile small tools, small repair parts and supplies.

1 5-ton wrecking truck with either derrick or winch.

2 5-ton cargo trucks for the larger and heavier spare parts, such as complete axles, transmissions, etc.

1 $\frac{3}{4}$-ton cargo truck for equipment of personnel.

1 5-ton 4-wheel tire-press trailer.

1 5-ton stock-room trailer.

1 light 2-wheel office trailer.

1 light touring car.

Shop Trains for Water-Supply Companies.

The water-supply companies engaged on active work in the field have, from the very nature of their activities, a great deal of small shop-work to do, requiring machine-shop equipment, blacksmith and carpenter outfits, plumbing, metal working, etc. The question of working equipment for these companies has two phases. On the one hand, each company must be provided with a suitable assortment and quantity of tools and supplies which will enable a considerable number of working parties to be sent out on different jobs of water-supply work, each properly equipped for its job. On the other hand, there must be facilities at some central point which will enable the company commander to do, without delay, and without embarrassment for lack of reasonable facilities, many jobs of simple shop work, which time and distance and need for conserving transportation and man-power make it impracticable to send to some remote shop, where, even if convenient to send it, shop conditions might not permit prompt attention to each small job. These conditions, experience in France has shown, point to the urgent need of a reasonable shop equipment in the hands of each water-supply company.

The General Engineer Depot in Washington has developed a type of shop train consisting of 4 motor trucks, as designated below, mounted with suitable equipment:

1 machine-shop truck.
1 blacksmith-plumbing shop truck.
1 carpenter-shop truck.
1 supply truck.

One of these trains complete should be considered as an essential part of the working equipment of each battalion headquarters of the water-supply regiment of each army, and in addition, each company should have one fully equipped machine-shop truck.

Additional Labor Troops.

It has always been recognized that the water-supply regiment by itself would not suffice to take care of the water-supply work in an entire army area under all conditions. This would be especially probable in occupying a new area in which no extensive and systematic preparation had been made for water supply, or in occupying an area desolated by the enemy, or in active preparation for an offensive.

At such times as these, additional troops are required. In order to meet the water-supply requirements of the First Army during its preparation for the St. Mihiel offensive, certain companies of the 27th Engineers (mining), and the 37th Engineers (electrical and mechanical), were attached to the 26th Engineers, bringing the total working force on water supply in that area up to approximately 7 companies. The companies of the 27th and 37th Engineers were not selected primarily because of special qualifications, but rather because they were available and not otherwise engaged on any important work.

During the offensive between Verdun and the Argonne, three companies of pioneer infantry were temporarily assigned to the Water-Supply Service, and attached to the several companies of the 26th Engineers operating in that area. The substantial increase in labor thus resulting enabled the skilled labor of the water-supply companies to extend further and be more effectively used. The results of thus attaching pioneer infantry have been

satisfactory, and this must always be considered an essential feature of the army Water-Supply Service.

Labor troops are valuable in proportion as the warfare becomes one of fixed position.

Additional Officers for Staff and Special Duty.

The various activities of the office of the water-supply officer, army, demand a suitable force of energetic, enterprising officers who are experienced in the fundamentals of water-supply work. Besides the water-supply officer, whose responsibilities and duties are heavy and exacting, a principal assistant or deputy is required; also a supply officer, who may be the regimental supply officer, but whose duties will be far heavier in connection with the supply of materials for the army water-supply work; also a water-supply intelligence officer, to follow constantly all possible sources of information relating to water resources in the region occupied by the army and to guide in a general way the outlining of the broader phases of the program for water supply for the entire army; also an officer charged with responsibility for the water-supply laboratory and sanitary-inspection phases of the army water-supply work; also an officer to handle the general administrative work of the office and of the regiment, probably the regimental adjutant, with such assistance as he may require. The above list of officers for an army water-supply organization is the result of experience under the conditions our armies have met. Other conditions might demand considerable variations from this list.

Large Quantities of Materials Required.

I recall the conditions that existed on the British front after the Boche drove the British back toward Amiens early in 1918, and then later in the summer when the British drove the Boche back over the same territory. There was an enormous loss of material. In the British retirement toward Amiens they left behind, of course, practically all of their equipment in the field. They were able to salvage a little bit of the movable equipment, pumping machinery, and light stuff, — but very little, because

they were driven back very rapidly. It was to all intents and purposes a dead loss. And also large quantities of material they had stored within a few kilometers of the front was a dead loss. They had then to establish their water supplies for their combatant forces in the new positions which they had to take up, where they had been driven back.

Then a few months later, when they made the advance and drove the Boche back to and over the Hindenburg line, the whole area had been practically denuded of its water-supply facilities, because the enemy had taken special care, as he went back, — and he went back a good deal slower than the British had — to wipe out every bit of useful equipment. There they were, then, faced with an advance over an absolutely desolate area, nearly as desolate as a floor as far as water-supply equipment left there by the Boche was concerned. The water resources were there in the holes down in the ground, many of which they did not destroy. This, of course, meant the consumption of a large quantity of brand new material, and the installation of new water points. The rate of consumption of pipe and of pumps and all other equipment in connection with movements of that sort is simply astonishing. I won't give you any figures except just one to illustrate its magnitude.

In our plans for the future — we were then faced with the possibility of something of that sort ourselves if the war should go on for many months more, and if we too should be subjected to a serious backward movement, and we therefore considered it prudent to take the highest figures — that is, figures based on the worst conditions that the British had been subjected to — as a basis for our estimates of quantities of pipe and of pumps that we ought to put on order, especially as it took anywhere from eight months to a year from the time of writing an order and putting it into the hands of the staff in France, until we would actually get the pump or the pipe on the ground ready to put into place. Therefore, with eight to twelve months' time to get deliveries, you can see we had to make provision, and ample provision, for a large margin of safety. So that the one figure I was going to quote you was this: We had on order 90 miles per month of 4-in. steel screw pipe, and that was based on the actual

loss and consumption of the British during their severe campaign of early 1918.

WATER CONSUMPTION OF ARMIES.

It is, of course, necessary to have some figures of motor consumption set as a guide to an engineering force in the field, to serve as a basis for design where time and the exigencies of field service permit such consideration to be given. In many situations this cannot be done. The quantities that can be made available will frequently be limited by the meagerness of local natural resources, by the shortage of time during hurried preparations for an attack, by limitations of equipment or materials, by imperfect information as to the number of troops or animals to provide for, or by various other conditions incident to the military situation. They may thus bear no relation to the unit quantities considered as desirable.

The Commander-in-Chief, in a communication dated November 15, set a limit for water to be supplied at semi-permanent cantonments and billets at 10 gal. per man per day, and for hospital use 25 gal. per man per day. The data relating to water consumption at British hospitals given in Appendix 20 indicate clearly that 25 gal. is an unnecessarily large allowance for all hospitals. For extensive hospitals of the barrack type, such as the 1 000-bed units and the 300-bed units adopted as standard by our Medical Department, 10 gal. per man per day for the maximum population of the hospital, including patients and staff, should be sufficient.

A consideration of the data given, together with all of our field experience, indicates that for water-supply construction work with the armies in the field an allowance of 2 gal. per capita per day for men and 10 gal. for animals, with proper consideration for special conditions such as the filling of water-tank trucks, light railway cars, etc., will assure quantities which will enable the troops to pursue their activities without suffering for want of water. Compilations of figures for water consumption in the field have been made. They vary widely, some of them being less than the quantities here stated. It is known that large masses of men and animals have under stress of necessity carried

campaigns to a successful termination with much smaller quantities of water than these.

Horse Watering.

The organization tables call for about 7 500 animals, mostly horses, for each division. In addition, when considering a corps or an army, there must be taken into account the animals required for special corps or army service and for trains. Including these additional animals, the total number of animals in each division for which water may have to be provided may be taken as about 9 000. On the basis of 20 combatant divisions per army, this would make, without counting any attached cavalry, about 180 000 animals per army.

The magnitude of the animal problem may be judged from this statement of the Remount Service, that the British had brought about 500 000 animals to France in connection with their military operations, and from the statement in a French report that 175 000 horses were concentrated back of Verdun, and during the advance in the summer of 1915 the Third French Army was provided with about 1 animal to each 3 men.

One of the most important factors of the program for the army water-supply organization is the providing of water for the animals. Animals can, of course, be watered in flowing streams or in ponds, and this is done and must be done to a large extent. An army cannot always depend, however, on finding suitable streams for this purpose. Even if it does find them, they are not a satisfactory means of watering animals, for a number of reasons. Where animals are watered in a stream, certain points that can be conveniently reached by the animals will of course be used. Unless the conditions along the bank of the stream are unusually favorable, these points are likely to become mires after a large number of horses have watered there. It not infrequently happens that horses get down in such holes as these, are unable to extricate themselves, and are drowned.

A flowing stream is also sure to be used as a source of water supply for soldiers, usually with treatment, but undoubtedly to some extent without. It is obviously desirable, therefore, to

prevent as far as is possible the pollution of such a stream. A large measure of pollution can be prevented by providing some other means of watering the animals, thus obviating the necessity for large numbers of animals and men going down to the streams.

Attention to Fundamental Principles.

The layout and the construction of horse-watering points require close attention to a number of important principles to give satisfactory results. First of all, of course, the arrangement of the troughs, their capacity, and the hydraulics of the system, must be considered; the difficulties that may arise from congested traffic conditions must be recognized; other conditions, such as concealment, suitable drainage, protection of roads, segregation of infected animals, etc., are all of varying importance, depending upon local conditions.

Types of Troughs.

Numerous different types of horse-watering troughs have been used by the Allied armies. The most common type has probably been the wooden trough. The French have made these in large quantities, of a simple design which permits indefinite extension of the length of the trough. The French troughs, however, very commonly have the difficulty of too small a capacity. Many of them have been noted which serve well enough for the few horses which use them during quiet periods, but which would be utterly inadequate for large concentrations of horses. British experience has indicated the advantage of having a substantial amount of storage in the trough itself, in order to take care of the maximum rate of watering during concentrations. The British have also used wooden troughs extensively, but there has been considerable restriction on the use of wooden troughs on account of the scarcity of lumber.

Concrete troughs have been used to some extent. The conditions of field service during the periods of activity, of course, do not permit such permanent construction as concrete troughs imply. The Water-Supply Service of the American armies has

not built many concrete troughs. Conditions throughout 1918 have generally been too active to permit of any but the simplest and most hasty construction. Warfare of position, such as the Allied armies were engaged in during three years, more or less, permitted the construction of elaborate and more permanent structures, and there are among the British works, especially, many structures of types which the American Water-Supply Service did not build at all.

Sheet-steel water troughs have been extensively used. The British had certain types of steel troughs which served their purposes well, and the American Army was beginning to make use of them toward the end of our campaign, and had a rather extensive program of production arranged for. Considering all conditions, the steel trough appears to offer the greatest advantages. It is light and durable, and it does not require large quantities of wood. It can be made so that the sections nest, thus reducing the bulk and facilitating transportation, and it can be so designed as to permit of indefinite extension in length. The American Army experience had not gone far enough to crystallize standard types of trough, but the tendency was strongly in the same direction as with the British.

Quantities of Water for Animals.

There are many fragmentary records relating to the quantity of water taken by animals. The conditions vary a great deal in the different statements. It would appear that the average daily consumption of large numbers of horses might be 5 or 6 gal. per head during the thirsty periods and while the horses are at work, and considerably less than that in weather that does not encourage animals to drink much and when they are not working; in a broad way, an assumption of 10 gal. per head per day as a basis for design will assure adequate capacity of the water point. The importance of getting the proper relationship between the varying demands, the pump capacity, and the storage provided, should be emphasized.

History of the 26th Engineers.

There is a large amount of extremely interesting data, the story, as you might say, of the activities of the water-supply regiment in France, which was written up as an official history which now reposes in the archives in Washington. Both officers and soldiers of the organization wanted that history for a permanent place on their library shelves. A program was therefore arranged for a rewriting of it in some more popular form than the dry recital of facts presented to the War Department, and it has been so rearranged, and it is to be published as a paper of the New England Water Works Association. It will not be read before the Association, but I will refer to it now as the history of the 26th Engineers, the water-supply regiment, and their activities in France. It will appear shortly as a separate number of the Journal of the Association.

Discussion.

Mr. Frank L. Fuller.* I wish Colonel Longley would tell us a little bit about the driving of some of these wells, if it won't take too long. I should like to hear about the mechanical work that was done.

Colonel Longley. Very few wells were driven on the American front. Our activities in the combatant areas were moving too rapidly for the driving of wells. There were many wells driven in the work on the lines of communication. There were some very deep wells driven. At Bordeaux there were some wells driven which I think went down about a thousand feet.

Mr. Fuller. How large were those wells?

Colonel Longley.† I think th yestarted with a 10-in. casing and wound up with a 6-in. There was a large flow from them. One of them, I think, delivered a half-million gallons a day. It was a good well.

Mr. Fuller. Any as small as 2-in.?

Colonel Longley. Very few as small as that in the field,

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* Civil Engineer, Boston, Mass.

† Consulting Engineer, New York, N. Y.

but on the lines of communication there were many small well points put down. We had a large quantity of well-drilling equipment over there, most of it purchased in the United States, and a little equipment from England, much of which was put to very good service. After the British lost so much of their equipment in the great movement they had to make in 1918, we turned over to them quite a bit of well-drilling equipment. They made much more use of wells than we did, for the reason which I think I referred to as I went along, — the fact that the geological conditions in the areas they occupied were more favorable for getting large quantities of water from wells, which were drilled very easily, because the earth was chalk, and it is saturated with water at a depth not far below the surface. But in all the areas that we were occupying drilling was difficult. The rock was fairly hard, and the yield was small, so that the time element came in there, and we did not do very much development of water supplies by wells at the front.

MR. FULLER. You got the surface water in shape quicker than you could drill the wells?

COLONEL LONGLEY. Yes.

MR. FULLER. Did the Germans do much in that line?

COLONEL LONGLEY. No. I was astonished, really, at the small amount of systematic effort that the Germans seemed to put into their water-supply work.

MR. FULLER. They had to drink water, didn't they?

COLONEL LONGLEY. They used bottled waters to a very large extent, but not exclusively water, Mr. Fuller.

DESCRIPTION, OPERATION, AND PURIFICATION EFFECTED BY DRIFTING SAND FILTRATION SYSTEM IN TORONTO DURING 1918.

BY NORMAN J. HOWARD, M.AM.C.S., BACTERIOLOGIST IN CHARGE, FILTRATION PLANT LABORATORY, TORONTO.

The purification of the water supply for the city of Toronto is effected by means of two systems, one being a slow sand and the other a mechanical of the drifting sand type. The water is drawn from Lake Ontario to the south of Toronto Island, two intakes being situated a little over 2 000 ft. from the shore, submerged in about 60 and 80 ft. of water, respectively. The slow sand system has given excellent results, but when an extension was found necessary in 1914, the city decided on mechanical filtration, the reasons given being, difficulties in operation, caused by a combination of occasional high turbidity and the low temperature in the winter months.

The object of this paper is to give as briefly as possible, a description of the drifting sand system and the results of the operation and purification effected during 1918. Throughout the paper the word " gallons " are Imperial gallons. The capacity of the plant is 60 million gallons in twenty-four hours, but a maximum rate of 72 million gallons daily must be maintained for a period of ten hours. The rate of filtration is somewhat higher than is usual with mechanical plants, the rate being 150 million gallons per acre per day. Before describing the plant it would be well to state the two principles involved in its operation. They are the introduction of a coagulant without sedimentation and the necessity for there being a drifting as well as a stationary body of sand in the filter. These would seem to be two great differences existing between modern mechanical plants of the gravity type, and the drifting sand gravity filter.

In the Toronto plant the water flows by gravity from the intake into a suction well, where the coagulant is introduced, the water being pumped directly to the filters.

Coagulation Plant.

The coagulation plant consists of a large storage bin in which is stored aluminium sulphate used for coagulation purposes. Through a number of control doors the chemical is automatically fed to two dissolving channels, the density of which is kept from 12 to 14 degrees Baumé (about 15 per cent. solution). The strong solution passes into a hydrometer chamber, where it is automatically diluted to the required strength. The hydrometer is poised in the solution between two valves, one discharging alum and the other water. Any vertical movement of the hydrometer opens one valve and closes the other. Thus the hydrometer tank is supplied with strong alum solution at the top, or water at the bottom, depending on whether the hydrometer is up or down. The tank is made of concrete, whilst the hydrometer is steel, thickly covered with paraffin wax, and has a displacement of 6 000 lb. of solution. It is weighted so as to just float in solutions of alum ranging between 4 per cent. and 10 per cent. Owing to the differences in the density of alum and water, circulation is maintained, a 10 per cent. solution of alum being approximately 5 per cent. heavier than water. The heavier liquid coming in at the top immediately starts traveling downwards and meets the lighter liquid rising upwards; at the point of discharge a perfect mixture is obtained, it being impossible to detect stratification. A beam with knife edges above the hydrometer, which is extremely sensitive, provides for permanent adjustment and also for altering the density of the solution. Along the beam is a scale of divisions graduated in one-tenth grains, so that by moving a weight the required strength of solution may be obtained. The solution of alum next discharges into an orifice chamber. A mechanical device regulates the discharge of solution which is proportionate to the quantity of water being pumped, this being indicated by a Venturi meter which is indirectly connected with the measuring slot. From the measuring tank the alum passes through a lead pipe to the suction well and is then pumped to the filters.

Pumping Station.

The lift of water from the well to the filters is 32 ft. The pumping station includes three electrically driven pumps with a combined capacity of 100 million gallons and a lift of 32 ft. Besides these, there are a two-million gallon auxiliary pump with 32-ft. lift, two half-million gallon backwash tank pumps with 100-ft. lift, two one-million gallon drainage pumps with 20-ft. lift and two hydraulic-pressure pumps, with a capacity of 8 640 gal. a day under 700 lb. per sq. in. The discharge of the main pumps is controlled automatically by the level of the water in the filter tanks, through pilot valves, operating hydraulic valves on the discharge of the pumps. There has also been installed a steam turbo-generator set, in case the electric power should fail.

Filters.

The multiple filter unit system was adopted in Toronto, and consists of ten units, each having a nominal capacity of 6 million gallons. Each filter is made of steel, is 14 ft. high, 50 ft. in diameter, and is divided into thirty smaller units. These units are nested together in two rings of 18 and 12 respectively. In the center of the filter is a space $16\frac{2}{3}$ ft. in diameter, in which is placed the raw water control balance. Each of the thirty units forms a separate quadrilateral unit with sand extractors, sand washer, and filtered water collecting system. For backwashing, an overflow channel 15 in. wide and approximately 3 ft. deep is placed round the outer ring. At the bottom of each filter, partly embedded in the concrete, is a cast-iron collector pipe for the filtered water. Running out from the collecting pipe are a series of $1\frac{1}{2}$-in. wrought-iron sherardized pipes, having $\frac{3}{8}$-in holes drilled on the underside, spaced about 6 in. apart. These pipes have a cap on the outer end and the inner end is screwed into the cast-iron collector. On the top of the pipes is rounded gravel in three grades, varying from $\frac{3}{4}$ in. to $\frac{3}{16}$ in. to a depth of 10 in., and above this is 9 ft. of sand. The total amount of sand in each filter is 600 cubic yards. No screens are used between the gravel and the sand. The sand has an average effective size of .375 mm., and a uniformity co-

efficient of from 1.6 to 2. Around each small unit is a system of slots, and the drifting sand is withdrawn from the filter by means of extractor pipes, through which the sand flows to the bottom of the filter unit into a sand washer. At the sand washer the sand falls to the bottom through a current of raw water and is thus cleaned. It is picked up by the incoming raw water and carried back to the filter. The dirty water impurities or suspended matter pass upward and out at the top of the sand washer by an outlet suitably controlled. A water jet is provided to assist the flow of sand through the extractor pipes, and, below the point of discharge, a glass inspection port is provided, so that the flow of sand from each extractor pipe can be observed. The sand washers are of cast iron. The throats are relined when occasion arises, with wrought-iron pipe liners, specially hardened by a carbonizing process. The liners are in three steps and are 13½ in. high.

Operation.

The coagulant is introduced as the water goes direct to the filters, on the suction side of the pump. Owing to the operation of the drifting sand system, the sand contained in the filters resolves itself into two bodies — a stationary sand body supported by the gravel resting on the water collecting system and a drifting sand body lying between the surface of the stationary sand and the sides of the filter. By causing the sand to drift across the path of the raw water, a large proportion of the impurities, including the aluminium hydrate and the bacteria which have been caught up by the coagulant, is carried out along with a portion of the drifting sand. The stationary sand takes out the remaining impurities. The treated raw water enters the filter partly by a standpipe running through the center of the unit, which passes through a sand washer in the bottom, and delivers above the sand at the top of the pipe, and partly through a by-pass. Within the sand washer the raw water pipe is constructed similar to that of the tube of a Venturi meter and the drifting sand after being collected and washed in the sand washer is inducted into the raw water at the throat of the Venturi tube. This sand passes up the standpipe with the raw water and is delivered at the top of the filter. The

drifting sand forms a volcano-like cone that continuously drifts away and is being replaced with the washed sand from the sand washer, leaving a round top body of stationary sand below, resting upon the filtered water collecting system. The final purification is dependent on this body of stationary sand. The rate of flow of water passing through the by-pass may be varied in such a way as to suit the conditions of the raw water. In times of high turbidity the speed of the drifting sand is accelerated by decreasing the flow of raw water through the by-pass and increasing the flow through the standpipe. When in operation the stationary body of sand is found to be hard and compact with a cone-shaped-like surface, which is hard to penetrate. The drifting sand is of a buoyant and spongy nature and offers little resistance to penetration. In practice it is found that the slope of the drifting surface cone is a minimum of about 32 degrees and the slope on the surface of the cone forming the stationary sand is about 64 degrees.

Loss of Head.

The initial loss of head in the filters is 6 ft. and in the process of operation this gradually increases to 11 ft., when the filter is backwashed. Length of run of filters ranges between one and seven days according to the physical condition of the raw water and the amount of alum applied. Backwashing is accomplished by reversing the flow of filtered water through the bottom of the filter. The water is obtained from an elevated tank having a capacity of 200 000 gal. and which, on account of its elevation, supplies a natural head of 25 lb. Half the contents of the tank are passed through the filter at a gradually increasing rate, the first 100 000 gal. taking fifteen minutes, while the remaining quantity is passed through rapidly, the whole operation being completed in twenty minutes. The filter is then run to waste for twenty minutes, after which it is put into commission. The amount of dirty waste water passing through the sand washer is 2 per cent., while an additional 1 per cent. to 2 per cent. is used for backwashing and waste purposes.

Problems Encountered.

On a big plant embracing an entirely new system, it was expected that numerous problems would be encountered, particularly when the plant was put in commission, but with few exceptions, the difficulties have been overcome, and in no case can they be considered serious. In the early days, the biggest problem was to get a high-grade sand; about two thirds of the sand originally placed in the filters, amounting to over 4 000 cu. yd., had to be taken out and replaced at the expense of the contractors. At present the sand, while being satisfactory, is not quite uniform, having an effective size which varies between .35 and .4 mm. In the chemical house some inconvenience was caused by the corrosive action of the aluminium sulphate solution on the slotted trunk, through which the solution is discharged into the raw water. The trunk was made of vanadium silver, which has since been replaced by one made of pure copper. Tests are at present being conducted in the laboratory on a composition consisting of copper 92 parts and lead 8 parts containing 1 per cent. of antimony.

Sand Scour.

The question of sand scour has been the most troublesome. When the filters were first put in commission, the cast-iron throats did not wear as long as was expected, and they were relined, first with extra heavy black iron pipe and finally with similar pipe carbonized. Porcelain was tried but was unsuitable, and experiments with rubber are now under way. Most of the scour observed has been traced to a tail eddy, which forms at the back of the sand nozzle by the water passing it. By using the modified sand washer base the scour has been greatly reduced, and a number of new washers are being installed. Examination has shown that practically no scouring has occurred in the throat of the modified sand washer, after four months' continuous use.

Some trouble was caused in one filter by too rapid backwashing, which resulted in the disturbance of the gravel. The filter was emptied and the gravel replaced by 4 in. of 1 in. gravel and 6 in. of cemented gravel, in the proportion of 15 of gravel to 1 of cement.

The gravel used was the material which passed through a screen three meshes to the inch, and was retained on a screen having five meshes to the inch. This has proved to be very satisfactory.

Preliminary Experiments.

Prior to the completion of the new drifting sand plant at Toronto, extensive laboratory experiments were carried out over a period of eighteen months, the object being to collect as much data as possible that would likely be of value when the plant was put in commission. After six months' observation it became evident that the water of Lake Ontario was going to be an extremely difficult water to treat mechanically. That is to say, the purification effected after coagulation, under apparently the same physical conditions, varied from time to time. It was generally known that the quality of the water was governed by the meteorological conditions, which also controlled the temperature of the water. In the summer months, when the water was warm and the wind from an unfavorable direction, the water was invariably polluted. During the winter months the same unfavorable meteorological conditions produced a polluted water, which showed a drop in temperature instead of an increase, such as usually occurred in the summer months. This was explained by off-shore currents, which carried the shore water out, and at the same time met and mixed with the polluted water, which, in turn, was carried across the intake. For the laboratory experiments two small rapid sand filters were fixed up and sterilized. Raw water treated with amounts of aluminium sulphate, ranging between one half and three grains per Imperial gallon, was then passed through under varying conditions at the rate of 120 million Imperial gallons per acre per day. The removal of bacteria in the effluents was pro rata to the quantity of alum applied, the results being strikingly uniform. The time element was next studied, and the tests were made to determine what difference existed in the final purification between treated water after fifteen minutes' coagulation and after a period of three hours' coagulation and sedimentation. Little differences were noted, and the opinion was formed that the time element was not a factor in the resultant purification. Simi-

lar experiments were carried out in Ottawa with river water, by Joseph Race, city bacteriologist, and he found that the results between periods of two and one-half minutes and two hours were substantially the same. Tests were duplicated in the warm weather, and it was then noticed that the purification figures obtained under similar physical conditions in the summer months were considerably lower than were obtained in the winter months.

In 1918, when enough units of the new plant had been completed so as to allow testing to be carried out on a large scale, many of the observations proved of great value, and showed that the coagulation trouble that had been anticipated, actually worked out similarly to what occurred in the laboratory in the small experimental filters. Among other observations made were the resulting purification after coagulation and filtration of:

1. Lake Ontario water containing different degrees of turbidity.
2. Lake Ontario water free from pollution.
3. Lake Ontario water heavily polluted, winter conditions.
4. Lake Ontario water heavily polluted, summer conditions.
5. Temperature conditions of Lake Ontario water.

Turbidity did not help or hold up purification at any time of the year. The only effect was to cause an increased amount of alum to be applied at such times as was considered necessary for clarification purposes. Water free from pollution offered no difficulties. In the winter months a polluted water required at least one and one-half to two and one-half grains of alum in order to get a satisfactory effluent. During the summer months it was found necessary to apply at least two and one-half grains per Imperial gallon to a polluted water which was often free from turbidity. Water slightly polluted required about one grain per gallon. No satisfactory explanation of the varying conditions can be offered, although much experimental work has been carried out to determine what are the controlling influences. There is no doubt temperature conditions play an important part, although it has been generally conceded that warm water aided coagulation. In Toronto the raw water appeared to coagulate slightly better in the summer months when the water temperature exceeded 50 degrees Fahr., but the final purification effected was lower than in the winter period, when the water temperature ranged between 33 and

46 degrees Fahr. The microscopic content showed a great increase in the summer months, as also did the total number of bacteria present; these, again, might be a contributory cause. The most logical idea is that the colloidal content of the water in some months was largely responsible for the conditions noted, and that a direct relationship existed between the microscopical, bacteriological, and colloidal content. When the preliminary tests on the drifting sand experimental plant of one-half million gallon capacity were carried out in 1914 by Colonel Nasmith and Captain Adams, Humber Bay water was used (this was Lake Ontario water into which the Humber River flowed), and splendid efficiencies of over 98 per cent. were obtained on a test period of thirty-six consecutive days.

Purification Effected in 1918.

The appended tables show:

1. Average amount of water filtered; amount of aliminum sulphate applied; turbidity in raw and filtered waters.

2. Average number of bacteria per cubic centimeter growing on standard agar in twenty-four hours' incubation at 37 degrees C. in:

(*a*) Raw, filtered, and chlorinated water, together with percentage reduction in filtered and chlorinated water, all results included.

(*b*) Same as above, exclusive of three results for reasons specified.

3. Same figures, classified under summer and winter groupings.

4. Tests for typical *B. coli*, forty-eight hours at 37 to 39 degrees C., showing number of days present in raw, filtered, and chlorinated water. Indicated number of *B. coli* per 100 and 1 c.c. in the raw and filtered water, together with the total percentage reduction.

(*a*) All results included.

(*b*) Exclusive of three results for reasons specified.

With the object of showing the different degrees of purification effected in the two seasons of the year, two periods were grouped, the first being from December to May, and the second from June to November. The month of June produced a water that was easy to treat at all times, but for classification purposes was placed in the second period.

It has been previously mentioned that the raw water is subject to rapid changes. Frequently the water becomes heavily polluted after less than eight hours' change in the meteorological conditions. This makes the treatment exceedingly difficult, as occasionally a sudden polution has occurred and an insufficient quantity of alum applied, with the result that the efficiency of the plant has been impaired. Regarding the expression of results, inclusive and exclusive, it was felt that an explanation should be offered for same. The results excluded are, one in September and two in October, the reasons being that on two occasions abnormal pollutions occurred when the bacterial count in the raw water was in the neighborhood of 15 000 per cubic centimeter, and at the same time an insufficient quantity of coagulant (1.5 grains per gallon) was being applied. On the other occasion the alum was reduced too soon following a change in the direction of the wind. When chemical tests were made it was found that the water was still polluted, and consequently the alum was again increased. During the intervening period the sample was collected and proved to be unsatisfactory. As will be seen from the figures, the inclusion of these three results materially alters the average number of bacteria present, and also lowers the *colon* efficiency. It would seem to be scientifically incorrect to give only one set of figures, as a wrong impression might easily be formed.

The average number of bacteria per cubic centimeter growing on standard agar, 37 to 39 degrees C., was 369.5 in the raw and 53.4 in the filtered, inclusive of all results showing an average reduction of 85.4 per cent. Excluding three records for reasons previously specified, the figure was 303.6 in the raw and 34.7 in the filtered, with an average reduction of 88.4 per cent. The indicated number of *B. coli* per 100 and 1 c.c. was 612 and 6.12 in the raw and 31.70 and .317 respectively in the filtered, with a total average reduction of 94.8 per cent. If the three records before mentioned are excluded, the raw water would show 608 per 100 c.c. and 6.08 per 1 c.c., whilst the filtered water figure would be 22.0 per 100 c.c. and 0.22 per 1 c.c., with an average percentage reduction of 96.4. The chlorinated water showed an average bacterial count of 1.72 per cubic centimeter, while only two samples out of 1 900 samples examined showed the presence of *B. coli* in 1 c.c. This gives a total removal of 99.9 per cent.

Turbidity.

Particular attention has always been given to the clarification of the water, and it would be well to point out that the turbidity figures given are only those actually occurring at 9 A.M. daily. During the month of April the figure in the raw water ran up as high as 550 parts per million, and the maximum figure recorded in the table as occurring in the filtered water followed this high period of turbidity. The raw water figure given in the table as 160, was the degree of turbidity actually present in the raw water half an hour previous to the collection of the filtered water sample, this being the estimated time for the water to pass through the filter from the time the coagulant was first added.

Conclusions.

The original specifications called for certain efficiencies being obtained on an average amount of one grain per Imperial gallon of aluminium sulphate, this figure being largely based upon the results obtained on the experimental plant, on the Humber Bay water in Toronto. As a result of practical experience on the mechanical filtration of Lake Ontario water, considerable modification has had to be made as regards the operation of the new plant. Conclusive evidence has been forthcoming from experiments and borne out by actual results, that Lake Ontario water cannot be bacteriologically purified to a high degree by mechanical filtration, when only an average dose of aluminium sulphate of 1 grain per Imperial gallon is applied. The actual purification effected by the drifting sand filters, in 1918, was on an average application of 1.027 grains per Imperial gallon, and the results obtained on such a small amount are satisfactory. It has been clearly demonstrated (see diagram) that if a higher dose of alum was applied, a corresponding degree of purification was obtained. The economical question, however, had to be taken into consideration on account of the enormous cost of aluminium sulphate, and when it is considered that during periods of high pollution as much as 2.5 grains per gallon was applied, a definite economical as well as a practical policy of operation had to be adopted.

The summary of conclusions formed is as follows:

1. That Lake Ontario water can be treated effectively by mechanical filtration.

2. During the year the composition of the water appears to undergo two distinct changes, which make the treatment of the water difficult.

3. That in the summer months more coagulant is necessary than in the winter period.

4. That the purification effected by the drifting sand filters during 1918, upon an average dose of 1 grain per gallon of alum, was satisfactory.

Future Policy of Operation.

The plant is operated by the Department of Works, Commissioner R. C. Harris being the head of the department, with A. U. Sanderson as superintendent of the plant. The filtration laboratories, under the Department of Health, determine the amount of coagulant necessary. An excellent understanding has always existed between the two departments, and close coöperation on the plant has made its operation a simple matter. Our policy of operation as at present defined is:

1. Treat raw water at all times with sufficient aluminium sulphate to clarify the effluent effectively.

2. Obtain as high a bacterial efficiency as possible on an average dose of 1 grain per Imperial gallon.

3. Leave final sterilization to chlorine.

In conclusion, I would quote last paragraph from the official report on drifting sand filters, October, 1918, by Col. G. Nasmith and the writer, which reads as follows:

"The decision we arrived at when the tender for the mechanical plant was first let, 'That our former conception of a filtration plant was undergoing a material change; that sterilization of the water was the vital thing, from the public health standpoint, but that a filter was essential to clean the water, to keep the sand and dirt out of the water supply, and thereby prevent the wear and tear of machinery valves, taps, etc., as well as prepare the water for efficient sterilization; and that for a great portion of the year only a fraction of a grain of aluminium sulphate in conjunction

with a slight amount of chlorine would be essential for filtration, thereby resulting in a great saving in the cost of operating,' has been generally confirmed as a sound one, not only by ourselves, but by sanitarians in civilian and army work the world over." (See *Canadian Engineer*, issue of October 24, 1918, page 361.)

In connection with the preparation of this paper I am indebted to Col. Geo. Nasmith, director of laboratories; A. U. Sanderson, superintendent of the plant, and Messrs. Hannon and Thompson, of the filtration laboratory staff, for their advice and assistance.

TABLE 1.

Drifting Sand Plant, 1918.

Table showing average amount of water filtered daily, together with monthly average of applied aluminium sulphate and turbidity in the raw and filtered water.

Month.	Av. Amt. of Water Filtered, Million Imperial Gallons.	Av. Amt. of Aluminium Sulphate Applied in Grains per Gallon.	Turbidity. Raw Water. Max.	Turbidity. Raw Water. Min.	Turbidity. Raw Water. Av.	Turbidity. Filtered Water. Max.	Turbidity. Filtered Water. Min.	Turbidity. Filtered Water. Av.
January	30.95	0.98	80	1	6.2	under 1	under 1	under 1
February	33.16	0.65	24	1	3.9	under 1	under 1	under 1
March	33.63	0.92	54	1	12.7	3	under 1	under 1
April	32.49	1.48	160	1	27.9	18	1	2.4
May	32.74	1.04	7	1	2.1	under 1	under 1	under 1
June	31.76	0.82	2	1	1.3	under 1	under 1	under 1
July	39.13	0.61	3	1	1.5	1	under 1	under 1
August	38.00	1.08	10	1	1.8	1	under 1	under 1
September	36.9	1.02	25	1	2.8	under 1	under 1	under 1
October	40.61	1.2	4	1	1.4	under 1	under 1	under 1
November	44.19	1.07	35	1	2.9	under 1	under 1	under 1
December	37.7	1.3	75	1	21.3	under 1	under 1	under 1
Yearly average	36.0	1.027	..	.	....		under 1	

The average amount of chlorine applied to the water was .2 parts per million.

TABLE 2.

Average number of bacteria per cubic centimeter growing on standard agar 24 hours at 37 to 39 degrees C., in the raw, filtered, and chlorinated water, together with percentage reduction.

Month.	Raw Water.	Filtered Water.	Mixed Mechanical and Slow Sand Water Chlorinated.
January	42.2	3.3	1.2
February	7.4	1.2	1.0
March	43.0	3.2	1.6
April	73.4	5.6	1.0
May	28.7	5.7	1.1
June	108.5	11.4	2.8
July	97.1	19.9	1.4
August	653.0	67.3	2.4
September	738.7	82.5	1.4
October	1 382.5	29.1	2.5
November	779.8	78.1	2.7
December	534.4	33.3	1.4
Yearly average	369.5	53.4	1.72

Per Cent. Purification Effected in Agar.

A. — Average of 303 samples. Average of 1 900 samples.

Raw water.	Filtered water.	Chlorinated water.
369.5	53.4	1.72

Total average reduction.

In filtered water........85.4% In chlorinated water.......99.5%

B. — Same, exclusive of three results for reasons specified.

Raw water............303.6% Filtered water.............34.7%

Total average reduction, 88.4%.

TABLE 3.

Showing the variation that occurs in the efficiencies in the winter and summer month periods.

Average Number of Bacteria per c.c. in the Raw and Filtered Water with Percentage Reduction.			B. Coli Test. Showing Number of Days that *B. coli* was present in Raw and Filtered Water with Percentage Reduction.										
Month.	Raw Water.	Filtered Water.	Raw Water.						Filtered Water.				
			100	10	1	0.1	0.01	0.001	100	10	1	0.1	0.01
WINTER PERIOD.													
December	534.39	33.35	25	23	18	11	5	1	25	16	9	1	0
January	42.23	3.31	22	11	8	1	0	0	13	7	0	0	0
February	7.42	1.21	24	15	2	1	0	0	22	8	2	0	0
March	42.98	3.24	23	17	7	3	0	0	19	10	3	0	0
April	73.44	5.62	24	19	13	6	0	0	23	10	6	0	0
May	28.73	5.62	25	15	5	0	0	0	24	13	2	0	0
Removal, 92.8%.			Total removal, 97.8%.										
SUMMER PERIOD.													
June	108.54	11.38	21	14	2	1	0	0	18	4	0	0	0
July	97.08	19.92	22	14	4	1	0	0	24	14	3	0	0
August	653.2	67.31	26	24	15	4	0	0	26	23	9	0	0
September	738.6	128.80	24	19	11	5	0	0	24	16	10	0	0
October	1 382.46	290.5	26	21	15	9	0	0	26	18	7	2	0
November	779.6	33.32	24	13	7	1	0	0	25	19	7	0	0
Removal, 84.1%.			Total removal, 75.8%.										

TABLE 4.

Tests for typical *B. coli* 48 hours at 37 to 39 degrees C., showing number of days present in the raw and filtered water, and chlorinated water. Indicated number of *B. coli* per 100 and 1 c.c. in the raw and filtered water, together with the total percentage reduction. A. — All results included. B. — Exclusive of three results for reasons specified.

Month.	Raw Water.						Number of Samples.	Filtered Water.					Chlorinated Number of Samples Positive.	Chlorinated Percentage of Samples Negative.
	100	10	1	0.1	0.01	0.001		100	10	1	0.1	0.01	1 c.c.	.1 c.c.
January	22	11	8	1	0	0	26	13	7	0	0	0	0	100
February	24	15	2	1	0	0	24	22	8	2	0	0	0	100
March	23	17	7	3	0	0	25	19	10	3	0	0	0	100
April	24	19	13	6	0	0	25	23	10	6	0	0	0	100
May	25	15	5	0	0	0	26	24	13	2	0	0	0	100
June	21	14	2	1	0	0	24	18	4	0	0	0	1	99.4
July	22	14	4	1	0	0	26	24	14	3	0	0	0	100
August	26	24	15	4	0	0	26	26	23	9	0	0	1	99.4
September	24	19	11	5	0	0	24	24	16	10	0	0	0	100
October	26	21	15	9	0	0	26	26	18	7	2	0	0	100
November	24	13	7	1	0	0	26	25	19	7	0	0	0	100
December	25	23	18	11	5	1	25	25	16	9	1	0	0	100
Totals	286	205	107	43	5	1	303	269	158	58	3	0	2	99.9

A. — Indicated number of *B. coli* per c.c. —.

Raw water per 100 c.c., 612 — Filtered water per 100 c.c., 31.70
Raw water per 1 c.c., 6.12 — Filtered water per 1 c.c., 0.317

Total reduction inclusive of all results, 94.8%.
Chlorinated water, 99.9%.

B. — Raw water per 100 c.c., 608 — Filtered water per 100 c.c., 22.0
Raw water per 1 c.c., 6.08 — Filtered water per 1 c c., .22

Total reduction exclusive of three results for reasons specified, 96.0%.

Discussion.

Mr. Frank W. Green.* I should like to ask if, when you have a longer coagulation, it does not reduce the wash water, and also if it would not be better, considering it was made of steel and iron, to have as units the squares or rectangles, and also why the sand depth has to be so great.

Mr. Howard. Regarding the first question, it possibly would affect the loss of head, but we have found that the units go sufficiently long so that we do not have to bother about that. We get a normal run of anything up to ten days, with a minimum of one day, under very bad conditions. We get severe storms occasionally on the lake, in which large quantities of sand, not so much turbidity as large quantities of very fine sand, are thrown up, and there is a tendency to clog the filters. That sand is thrown out by the drifting sand process.

As regards the round filter units, that was simply a matter of design. The round unit design was accepted by the city. I believe in other places square units have been adopted, and I think that probably in the future they will be used wherever this system is adopted.

As regards the depth of sand, this is necessary because a minimum depth of permanent sand must be maintained at the point where the drifting sand passes into the extractor system. There is a depth of 26 in. at this point and there are 10 extractor pipes for each unit. The extractor pipes surround the unit and there are 30 units to each filter. It was considered absolutely necessary to have a minimum depth of permanent sand. It is obvious that if the whole body of sand was moving it would be impossible to get any purification at all. The final purification is entirely dependent upon this permanent body of sand.

Mr. G. A. Sampson. What is the total construction cost?

Mr. Howard. \$1 096 000. That was the lowest tender by \$100 000. We had another one of \$1 177 000; the next one was \$1 197 000; and the last one was an English tender of \$1 750 000, about \$650 000 higher than anybody else on this side of the pond.

* Superintendent of Filtration, Montclair, N. J., Water Co.

That actually was the last tender. Undoubtedly the prices had a bearing on the awarding of the contract.

MR. JAMES M. CAIRD.* During the time you had a low temperature of water and clearer water, I understand you to say that your period of coagulation was about twenty-five minutes?

MR. HOWARD. Actually about fifteen minutes. It takes eight minutes to pass through the filter.

MR. CAIRD. Did you have any trouble with alum passing the filter at that time?

MR. HOWARD. We got a slight trace of aluminium hydrate. It is almost invisible. We run a daily test not only on the mixed effluent but on every unit. There is a slight trace of aluminium hydrate in the filtered water. There are mighty few mechanical plants of any type using aluminium sulphate where you will not get a trace of the aluminium hydrate. We experimented by passing the filtered water through very fine filter papers and found that the hydrate was not decreased in any way.

MR. CAIRD. Doesn't that seem to tend to coagulation somewhere in the distribution system and cause some troubles around the distribution system in getting a mass of that out at times?

MR. HOWARD. We have taken water containing what we considered a little more than the average, when we have had a high dose of alum in, — 2½ grains. There was an increase of the aluminium hydrate in the effluent: it was at all times small, but it was there. We took the water and allowed it to stand under varying conditions to see what the result would be, and found that it disappeared after standing twenty-four hours.

MR. THEODORE HORTON.† Do you have any trouble in the distribution system from corrosion due to the passing through of alum?

MR. HOWARD. No, none at all. The plant has been in service now since about November, 1917, and we have not noticed any increase; in fact, we have had no complaints anywhere.

MR. GREEN. What is your carbonic acid?

MR. HOWARD. It depends upon how you estimate that. If you take standard methods, — that is to say, the standard methods

* Bacteriologist and Chemist, Troy, N. Y.

† Chief Engineer, New York State Department of Health.

of the American Public Health Association, — testing with phenolphthalein, we get a reaction indicating that there is no CO_2 present at all; if we take our laboratory methods, in the presence of sodium chloride, we find that the water contains 3 parts per million of carbonic acid gas. That is actually increased in the effluent to about 4½ parts per million.

Mr. Caird. Are you having any boiler troubles?

Mr. Howard. The boiler troubles occurred in the early days of operation, but were overcome. We have had leakage trouble around the stays of the boilers. This was said in the beginning to be due to the boilers getting steam up too rapidly. When the power fails, the steam system is used. There have been times when the power failed for twenty-four hours. Originally, when talking about the hydroelectric power system, we were told that the power could not fail. The engineer said the power would never fail but for a few minutes at a time; and within a month it was off twenty-four hours. Our trouble was mainly attributed to too rapid firing of the boilers. It takes two hours, I think, to get up full steam; but our generator can be put in commission in half an hour.

Mr. M. N. Baker.* Will you please tell us what expert advice the city relied on before launching upon this rather bold experiment?

Mr. Howard. The city, as you are probably aware, had a very able engineer as consulting expert, and he, at the time, recommended slow sand filtration. The city did not act upon his report but relied on their own authorities to guide them in their system. No consulting engineer advised on this at all. They took their own engineers, the heads of the laboratory division, and after running a test advised the acceptance of this system.

Mr. Baker. Wasn't it based very largely upon the advice of the medical officer of health?

Mr. Howard. In all instances he had to O.K. the recommendations. The medical officer of health, representing the Health Department, O.K.'d the work of Colonel Nasmith, the head of the laboratory division, who conducted all the experiments. When the latter reported upon this matter, it had to go to the head of the department for approbation.

* Associate Editor, *Engineering News-Record*, New York.

MR. BAKER. Do I understand it was done on his recommendation?

MR. HOWARD. It was on the direct recommendation of the city engineer and endorsed by the medical officer of health. The contractors were always governed, and the city protected, by a clause in the specifications, which said that the water purification should be based upon one grain of alum under average conditions. There is no doubt but what under average conditions the water is perfectly well purified, using one grain or less of alum.

MR. GREEN. How many days do you treat on one grain or less?

MR. HOWARD. I think approximately at least two hundred days in the year.

MR. GREEN. What is the average?

MR. HOWARD. 1.027 grains. That is a point to consider in this paper, — that for the year 1918 we probably could have gotten higher efficiencies if we had wanted to. We demonstrated that clearly. But we were more or less tied to the grain per gallon, because at that time alum was costing us $93 a ton in Toronto, and we were using 8 tons a day. If you consider the amount of $700 or $800 for coagulation alone, you can see it was a very serious proposition.

MR. CAIRD. I understand you to make the statement that my experience does not bear out directly; that is, the fact that all plants that use sulphate of aluminium get alum in the filtered water. Now, I have had experience with a few plants, and if a plant is properly operated there would be no sulphate of aluminium or aluminium hydrate in the filtered water. I only have in mind one plant where I had any trouble with aluminium hydrate in the filtered water. In all the other plants there was no aluminium hydrate in the filtered water. Every test showed it to be absolutely free. And the statement that all these plants have aluminium hydrate is pretty broad.

MR. HOWARD. I do not say all plants; I say, mighty few plants do not get a reaction; I base that opinion upon statements of many sanitarians who have visited Toronto, and I have very carefully asked them if they ever had any trouble. Some of them said they had none at all, others have said it depended upon how much alum they applied. That condition applies absolutely to Toronto.

With a small amount of alum we get no aluminium hydrate; when we start climbing up we get a reaction.

MR. CAIRD. Isn't there a low point where you will get aluminium hydrate, when you put alum in the water and it refuses to coagulate?

MR. HOWARD. We have not found that. We have never found aluminium sulphate in the filtered water. If we did we would consider it a serious question.

MR. W. C. HAWLEY.* I should like to say for our plant, which has been operating for over nine years, that we have never had aluminium hydrate in the filtered water until some time in the last six weeks, when somebody dumped a tank of acid in the Allegheny River. That was caught within half an hour, probably. But in the early days of mechanical filtration one of the chief objections, especially on the part of physicians, was that the alum would go through, and would have a serious effect upon the interior mechanism of all those who used the water. It is not many years ago since a very determined effort was made in the legislature of the state of Pennsylvania to prevent the use of alum, and the idea of the man who presented that measure was that the alum was going through the water and the people would suffer. But through the efforts of Mr. Caird the legislation was killed.

MR. HOWARD. I take it that you are only referring to the hydrate; you are not referring to the sulphate, which would be a serious thing. I would agree with you if you said that the sulphate would be harmful to the intestinal tract. We have never had a trace of sulphate; I am only talking about the aluminium hydrate.

MR. GREEN. I should like to say that I have known of hydrate of lime at Little Falls, and of other cases of that kind. I should like to ask the last gentleman if he ever got hydrate of aluminium.

MR. HAWLEY. I do not think I ever did. We have not had any report on it.

MR. HOWARD. It is a good thing that this point was mentioned, because originally we were led to believe that there would not be any. While we got practically none, there is undoubtedly a trace, and when we got that in the first instance, got in touch

* Chief Engineer and General Superintendent, Pennsylvania Water Co.

with several people. Their replies led us to believe that it was quite a common thing and occurred on many mechanical plants.

MR. GREEN. I think in most cases it only lasts for a brief time and has no serious result. But I think in most plants where there are frequent tests made, there are occasions when there are slight traces.

MR. WILLIAM J. ORCHARD.* Will you discuss some of the savings which have been effected in reducing the amount of coagulant required by adding chlorine before the alum?

MR. HOWARD. We considered if we could get rid of what little suspended matter was present by the filters, without alum or by reducing the alum to a minimum quantity, and then sterilize the effluent with chlorine, we would be doing a good thing from a public health and also from an operating standpoint. The point involved from an operating point of view was that our loss of head would undoubtedly have been reduced, and we would have required less backwashing. We tried a Wallace & Tiernan installation out for about a week, and got excellent results. I might say that we picked a week when the water was very good to do this, and we proposed trying out waters of varying qualities before we definitely laid down our policy as to how we were going to operate. At the end of the first week we got practically sterile results in 100 c.c. By that time we were ready to go ahead with the chlorination plant, it having been previously erected on the assumption that we were to reduce the cost of chemicals by about $20 000 a year. We figured on saving in the neighborhood of 200 to 300 tons a year. At the price it was then, it amounted to $20 000. The water was also chlorinated as it was pumped at the other end of the tunnel, leading to the city. The medical officer of health refused to have the water chlorinated at both ends, for the simple reason that he felt sure there would be a taste in the water. Unfortunately for us, when we were at the end of our first week, the weather suddenly changed, and we got a susceptible water, in which a perceptible taste of chlorine occurred. Occasionally we get this condition in Toronto, but so far we have been unable to determine what is the cause. In this particular instance it was said to be due to the added amount of chlorine we were putting in at the filtration plant,

* With Wallace & Tiernan, New York.

although we were actually only applying .125 parts per million, which we considered insufficient to cause any taste. Nevertheless, these two conditions happened at the same time, and we were held responsible. The medical officer of health had not been aware of the new chlorine installation at the plant, and immediately gave instructions that it was to be cut out. In spite of many efforts made on our part to put this plant in commission again, we have been unsuccessful. The plant, in future, will be held in reserve and we will have to get along the best we can. We had certainly figured on a saving up to $20 000 per year in our operation when we installed it. Of course the public is an important factor to consider, particularly when a taste occurs in the water. We had so much experience in Toronto along that line before the filtration plants were put in operation that everything must be done to avoid a repetition of the prefiltration conditions.

MR. PAUL LANHAM.* I should like to ask what advantage is claimed for the drifting sand filter over the ordinary mechanical filters.

MR. HOWARD. We do away largely with sedimentation. The total area of this plant, which is capable of filtering 70 million gallons, is 1¼ acres. If the coagulation basins had been put in, it would have taken very much more land. In Toronto it might not have made much difference because the land was cheap and belonged to the city. In other cities, where the land has to be bought, the interest charge on capital for the necessary amount of ground, would make a considerable difference in the cost of operation of the plant.

MR. MORRIS KNOWLES.† I am sure we shall study this over with a great deal of interest as we read it in print. Many of us have been interested to know how this plant was received in the long run. It is rather an interesting bit of history to me that should not go unnoticed, that many scores of years ago filtration was used in Great Britain. In the latter part of the nineteenth century it was used on this continent, but lately a filtration development called the " American " or " mechanical " has gone on apace

* Engineer in charge of Waste Prevention, Washington, D. C.

† Director, Department of Sanitary Engineering, University of Pittsburg, Pa.; Consulting Engineer.

and has very much advanced. Now we find our English brethren are modifying the American form and introducing a system which perhaps, after all, will make some revolutionary changes in the art. I am sure we can all study with a great deal of profit these new things, because it is by such advancements that we may promote the cause of better water.

There are two things that occur to me that I shall be pleased if Mr. Howard will answer. I do not understand if the Toronto water is severely polluted or highly turbid, as we know some of our waters of the West and South are. Have any experiments ever been made with that character of water which would indicate how such a filter would act? Then again, have any experiments been made with another coagulant — namely, iron and lime — so as to indicate what could be accomplished under such conditions?

Mr. Howard. Regarding the first question, when the experimental plant was put up, river water was used and clay mixed with it; a turbidity of 880 parts per million was produced. That was passed through the filter with excellent results, the figures being in the official report. The Toronto water generally is highly polluted, and at times has high turbidity. We actually found in running the plant on a big scale that we required at least 3 grains per gallon to deal with a turbidity of 550 parts per million which occurred last spring. That turbidity consisted largely of clay, washed off the cliffs some five miles east of the plant.

We found one condition in this plant which it is necessary to catch in its inception. If we allowed the turbidity to get a hold in the filter without a sufficient quantity of alum, we would get turbidity in our effluent. In the month of April you will see in the tables there was a turbidity actually reported in the effluent of 18. That was the resulting turbidity from the night before. For a period of twenty-four hours it exceeded 500 parts per million, although the table only shows 160. The direction of the wind changed during the night, and when the morning samples were collected the raw water had gone back to 160 and a residual turbidity of 18 in the effluent. Possibly had one of us been on the plant at night — and we certainly will be in future — we should have added from 3 to 3½ grains of alum, which would have probably prevented the turbidity in the effluent.

As to the second point, — the use of iron sulphate was tried as a coagulant in the laboratory extensively, with the idea of applying it instead of aluminium sulphate. Our principal reason for discontinuing its use was that, so far as I remember, it caused a dirty deposit in the mixing tanks, and we thought it would be undesirable to pass it on to the filters. We tried another series of laboratory experiments, working with several kinds of chemicals, and made observations on the coagulation produced by aluminium sulphate in the presence of peptones, gelatines, and other ingredients. True, we had differences. In the summer period we were somewhat puzzled to explain the results, which we thought might possibly be due to the content of the gelatinous films which formed on the slow sand filters. We thought that some condition might be occurring in our mechanical plant which was interfering actually with the coagulant. For that resaon we added .1 part per million of gelatine to the water and then added the alum and found that it completely held up coagulation. It was instructive but did not convey anything new to us, and did not really explain what was the different condition occurring in the summer months.

MR. CAIRD. Did I understand that you washed those filters once a week under good conditions, and your wash water was two per cent.?

MR. HOWARD. Yes; dirty water, two per cent.; wash water, one to two per cent.

MR. CAIRD. When it came to washing every day under your extremely turbid conditions, what did the wash water amount to?

MR. HOWARD. A little over 4½ per cent. is the highest we ever had. We accelerated the flow of the drifting sand, and that helped us out quite a lot. By drifting the sand faster, the filters lasted longer. If each filter was backwashed once a day it would involve about 2 million gallons of backwash water being used. You can figure out the percentage. That is an extreme condition which would be more or less balanced by the small amount of water used during other periods of the year. For instance, we have had some units go ten days; we make a practice now of not letting them go over six days.

COL. FRANCIS F. LONGLEY.* I think the members of the Asso-

* Consulting Engineer, New York.

ciation have to thank Mr. Howard very sincerely for his extremely interesting presentation of this new and novel development of filtration. There is one point, however, on which little or no information has been given, and I think Mr. Howard has made a brief statement upon it which would be interesting to members of the Association. That is as to the relative costs of construction and the relative costs of operation of the two plants that are now operated side by side on the Island at Toronto.

Mr. Howard. While there are no figures available as to cost of operation, the cost would be about two to one. The mechanical plant costs twice the amount to operate that the slow sand costs. This would not be based upon the same amount of water, the slow sand plant would be filtering 32 000 000 and the mechanical about 36 000 000 million gallons. Actually, the question of chemicals is the big factor. I would not want to state this figure as an absolute one, but it is roughly in the neighborhood of two to one. The slow sand plant cost approximately $775 000, while the mechanical plant cost $1 096 000.

Mr. W. N. Baker. Before this discussion closes I think it is only fitting that some tribute should be paid to the great ingenuity that was shown by the engineers who designed this plant for the contractors. As far as I remember, the paper did not give the name of the engineer. It was Mr. William Gore, was it not?

Mr. Howard. Yes.

Mr. Baker. Mr. Gore, who is, I think, a member of the Institute of Civil Engineers, and who, I understand, was associated at one time with Mr. Deacon of Liverpool, the famous water engineer we have heard of in connection with the Deacon waste-water meters.

Another tribute should be paid to the people who were willing, as the contractors were, to risk such a vast amount of money on a process involving radical changes, although at this time I understand plants of large capacity were built at Kingston, Jamaica, and one or two other points, in England, yet it was risking a very large amount of money on a very radical process and going back to the first principles, you might say, as to the elimination of a period of free coagulation.

Those of us who are old enough to remember the court contest

which took place between the mechanical filter companies, when they were fighting themselves to death, about twenty-five years ago, will remember that that was one of the points of contention; things were fought out in court on the patent, and that question as to the necessity of a period of coagulation before the water went through the filters was one of the points in issue. We eliminated that and also saw a tremendously high rate of filtration. Now we should all look forward to the developments on the drifting sand filter, and as to what the cost will really turn out to be when those figures are available.

I should like to say one thing further, which applies to the position a great many cities find themselves in, and the risk that some of them seem quite willing to take in connection with new and relatively untried processes. There have been a number of cities in this country that now have suffered very materially in this way. It is an experiment, and when a new process for sewage treatment has gone far enough so that the city is warranted in putting in its money to try out that system, notwithstanding the fact that some contractors, some capitalists, are willing to come forward and put up the money, the city is nevertheless taking a great risk whenever it does anything of this sort, because if it needs a filter plant it needs it; it does not want to run the risk of having a very large and expensive plant built, litigation ensue, a long period pass by, and then find itself, as New Orleans in the early history of mechanical filtration found itself, without a filtration plant — a very remarkable and interesting case, a thing which at last contributed very materially to the ruin of the water company there and the final taking over of the plant of the water company by the city, the city building a rival plant, as you might say, and the company only getting a small amount of money for, as I understand it, a certain amount of main that was in the street.

Now, it is getting very late, but there is just one other thing I should like to speak of on this line, and that is, the intensely interesting feature of this is the drifting sand and the principle of mechanical agitation in connection with the treatment of water and sewage, — a thing which I think might well be investigated further than it has been. We have had it in Massachusetts.

There is a certain parallel which might be drawn between this

treatment of water and the treatment of sewage which has been recently experimented on in eastern Pennsylvania and elsewhere. We have there mechanical agitation and the lime treatment and electrolysis combined.

I think there is a very great deal in connection with this drifting sand process that certainly would repay thorough study. At the same time, I must agree that Toronto took a tremendous risk in building a plant of that size, practically without any engineering advice, as I understand it, at all, and I hope it will turn out that it was warranted in doing so and that the process will fulfill the expectations of the city in promoting it.

MR. CHARLES W. SHERMAN.* Before we adjourn I think we want to express our appreciation of Mr. Howard's courtesy in coming here and giving us this very interesting information, which so many of us have been anxious to obtain for some time.

MR. GEORGE A. JOHNSON (*by letter*).† The writer is particularly interested in Mr. Howard's paper for a variety of reasons. In the first place, the process is a radical departure from long-established practices in water purification; and, second, the drifting sand filter plant at Toronto has ever been enveloped in a fog of uncertainty respecting its cost of operation and practical performances.

In the winter of 1913–14, the writer was preparing a monograph for the American Water Works Association, entitled, "Present-Day Water-Filtration Practice," and learning of the probable decision on the part of the Toronto authorities to adopt the Ver Mehr drifting sand system in the proposed 60 000 000 gal. (Imp.) extension to the existing slow sand system at that place, sought to obtain reliable information about it, that he might refer to it in his then forthcoming article on water-filtration matters in general. He learned that Sir Alexander Binnie was alleged to be an advocate of the process, and as the time was short before his article went to press he cabled Sir Alexander for a statement regarding it. Sir Alexander replied that the only plant of this type he had seen was a small installation in Wales, but that he was impressed by it and thought highly of its possibilities.

* Of Metcalf & Eddy, Boston, Mass.

† Colonel, U.S.A., Utilities Division, Construction Division of the Army.

Correspondence with certain public officials in Toronto, and even personal inquiry on the ground, developed only the same line of indefinite information.

Prior to May, 1913, a test plant having a daily capacity of 500 000 (Imp.) gal. was installed by the Ver Mehr Company near the old West Toronto pumping station, and on May 21, 1913, turned over to the city authorities for official test.* This test was run between the dates of May 21, 1913, and June 27, 1913, and upon the results then obtained, and the recommendations of Dr. Nasmith, the Ver Mehr Company was permitted to put in a bid for the 60 000 000 gal. (Imp.) installation. Of the four bids tendered, the Ver Mehr bid was $1 096 000, as against the other three of $1 177 000, $1 197 000, and $1 750 000, respectively, and the contract went to the low bidder.

From the time the test plant was installed in May, 1913, until the present day, the writer has endeavored to obtain information relative to the cost of operation and maintenance of the new filtration works, but his efforts have thus far been without definite result. The 1915 article by Dr. Nasmith was scrutinized in vain for light on this important point, and it is with regret that even at this late date Mr. Howard seems unable to give the profession any information on this vital phase of the matter. In reply to a question by Colonel Longley, he sweepingly dismisses the subject with the reply that "there are no figures available as to cost of operation." Personally, the writer does not see how any discussion of the merits of the drifting sand filter can be of definite utility until some one is ambitious enough to relate the whole story and advise the public, not what this plant cost to build, as compared with what either a slow sand or the established type of rapid sand system might have cost, — even going so far as to grant that all three would produce an equally satisfactory effluent, — but what are the actual costs of operation and maintenance.

A somewhat mysterious phase in operating results is described by Mr. Howard in reply to a question by Mr. Caird relative to whether alum passes the filter. Mr. Howard states that "there

* The results of this test were reported out by George C. Nasmith and F. Adams, of the Department of Public Health, Toronto, in an article which appeared in *Engineering Record*, April 10, 1915.

is a slight trace of aluminium hydrate in the filtered water." Further on, he says, " We experimented by passing the filtered water through very fine filter papers, and found that the hydrate was not decreased in any way." Now, this is suggestive. All water-filtration men know that where aluminium hydrate is in suspension in water, that hydrate, no matter how finely divided the particles may be, can be removed by passage through fine filter paper; that is, if the texture is fine enough and there are enough thicknesses of the paper. If the resulting filtrate then reacts alum, the presence of undecomposed alum is proved, and not aluminium hydrate. All this suggests that as a sequence of a practically negligible period of coagulation in this process undecomposed alum may be passing the filters, later perhaps to become decomposed and form an undesirable deposit in the pipes, or to cloud the filtered water as it leaves the taps in the city. If not so decomposed, an active corrosive agent is thus present in the filter effluent. This point requires clearing up by Mr. Howard in his closing discussion.

From the information before him, the writer is not prepared to accept without question the Toronto drifting sand filter as a reliably efficient and economical process of water purification. It is ingenious and seems to satisfy the Toronto authorities; but it is not apparent that the citizens of Toronto desire the drifting sand process at any cost, and it seems quite unusual that a plant which has been operated as long as has this one should not have developed accurate costs, a statement of which the profession at large, and the taxpayers of Toronto assuredly, would appear to be justly entitled to. When these figures are published it is to be hoped that they will be so decisive as to set at rest, once and for all, the doubt now existing in the minds of a great many water-works engineers as to whether Toronto is actually receiving acceptable water purification service at reasonable cost.

TESTS OF THE UNAFLOW PUMPING ENGINE.

BY D. A. DECROW, OF WORTHINGTON PUMP AND MACHINERY CORPORATION, NEW YORK.

[Read October 3, 1919.]

The members of the New England Waterworks Association may not all have had opportunity to become familiar with the principle of the Unaflow steam engine, which is not particularly new though its successful development as a practical and economic commercial machine is quite recent.

It derives its name from the fact that the steam entering the cylinder travels through the cylinder in one direction. Its development in this country has been very greatly retarded during the past two or three years by stress of war work which crowded it one side, but it is now being actively taken up and developed by a number of steam engine builders.

Generally speaking, the principle of the Unaflow reciprocating steam engine is that of utilizing the heat energy of the steam in the cylinder during the period of its admission, expansion, and flow in one direction, the expanded steam being released or exhausted through ports or openings uncovered by the travel of the cylinder piston at that period of its stroke most remote from the point of admission. A typical Unaflow steam cylinder and a typical set of indicator cards from a condensing engine are here shown. (Fig. 1.)

Typical Unaflow Steam Cylinder and Indicator Cards.

The piston is at one end of the stroke with the exhaust ports uncovered. The arrow indicates the path of the steam through the cylinder. The steam enters the cylinder at one end and there is practically no change of temperature until the point of cut-off is reached. After cut-off, expansion takes place with a consequent

drop in temperature, and at this time condensation begins, due to the changing of heat into work. As the cylinder head is jacketed with high steam, no condensation takes place on the walls of the head; the condensation is on the wall of the piston, which is comparatively cool so that at the end of the stroke when the piston uncovers the exhaust ports the moisture of condensation is mostly at the exhaust end of the cylinder and as the steam expanding away from the cylinder head rushes out through the exhaust port

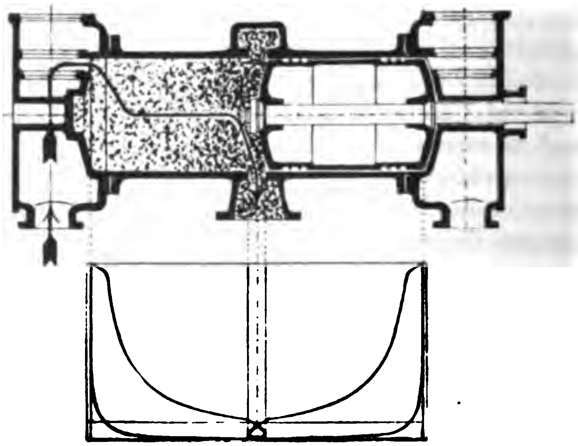
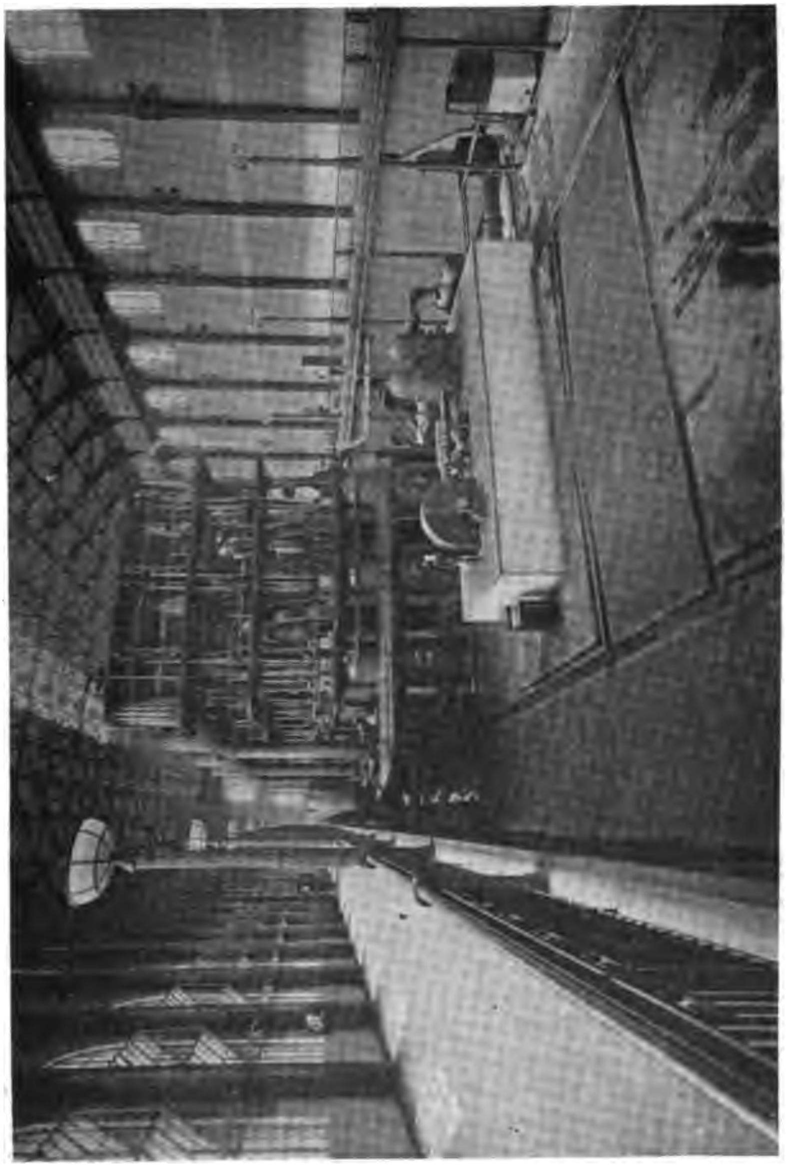


FIG. 1. TYPICAL UNAFLOW STEAM CYLINDER AND INDICATOR CARDS.

it takes the moisture with it. At this time there is a sudden drop in temperature in the cylinder, due to the sudden drop of pressure, but as the inlet end of the cylinder is dry it does not lose its temperature materially. The flow of heat from a dry surface being slow there is not time for any perceptible drop of temperature on these dry walls. The exhaust port is covered by the piston on the return stroke, trapping in the cylinder comparatively dry steam partially superheated. As the walls of the cylinder have retained their heat, the heat of compression is not absorbed either by moisture or by cold walls as in the case of the counterflow engine, and the steam remaining in the clearance is heated by compression to a temperature above the temperature of the initial steam; when the valve is opened to start the next stroke, the live steam

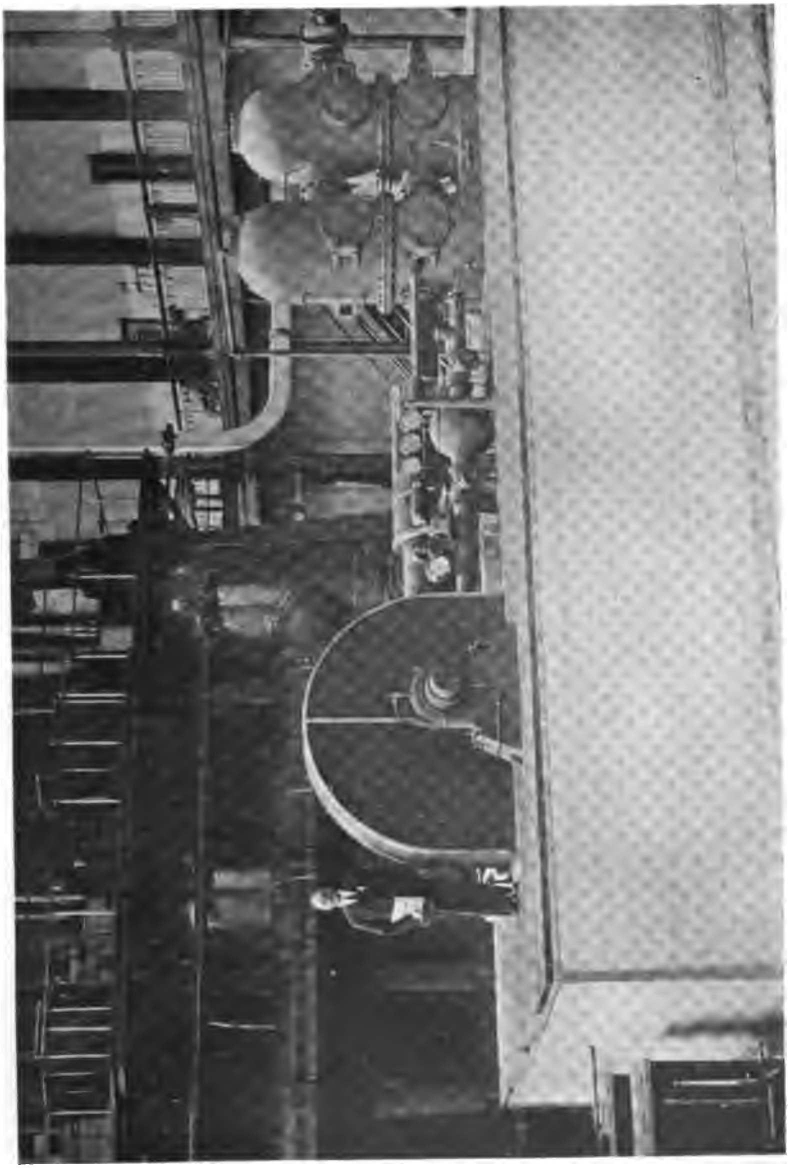


rushes into the clearance space in which the steam entrapped is hotter than the entering steam, hence no initial condensation. Owing to the removal of practically all of the moisture of each stroke, the well-known heat losses caused by the presence of water in counterflow engines are avoided.

It is also evident that leakage losses at the exhaust valves in the counterflow engines are eliminated. The absence of initial condensation permits a high economic ratio of expansion in one cylinder. There apparently is no particular gain in economy in compounding this type of engine.

Taking into consideration its simplicity and economy, the Unaflow engine seems to be a distinct step in advance of other types of reciprocating steam engines. Its advantageous features have attracted attention to it as a motive power for reciprocating pumping engines, and one of our pumping engine manufacturers has designed, constructed, and operated in the Porter Avenue Waterworks Pumping Station of the city of Buffalo a complete Unaflow high-duty condensing pumping engine of about 3 000 000 gal. daily capacity. This engine is of the horizontal type, having one steam cylinder and one double-acting plunger pump. It was designed for the following normal working conditions: Water pressure 100 lb. per sq. in.; suction lift, 15 ft. plus the friction in about 60 ft. of suction pipe; steam pressure, 235 lb. per sq. in., 100° F. superheat. It is shown in the foreground of this interior view of the Porter Avenue Station, five 30 000 000 gal. vertical triple expansion pumping engines forming the background, and in the two closer views following.

At the time consideration was given to the adaptation of the Unaflow steam engine to pumping practice it became apparent that in order to take advantage of its most economic speeds a marked improvement in pump valve and pump construction would be necessary, the basic feature of which was to develop a pump valve that would operate satisfactorily under all the varying conditions of speed and pressures to which pumping engines are liable to be subjected, and a valve was designed and constructed that seems to fulfill all of these requirements. It is shown with the flow of water through this type of valve compared with the flow of water through an ordinary standard pump valve.



For the purpose of testing this valve under various working conditions, a special power pump driven by a variable speed motor was constructed having a single acting plunger 2 in. diameter by 12 in. stroke. In this pump the pump valves were surrounded by glass cylinders so their operation could be readily observed, and were subjected to various tests, the pump being run at speeds ranging from 50 to 290 r.p.m. The maximum lift of these experimental pump valves was $\frac{3}{16}$ in. This pump valve was subjected to sixteen different tests for slippage, with the following results.

BUFFALO, N. Y., October 31, 1918.

EXPERIMENTAL HIGH-SPEED PUMP.

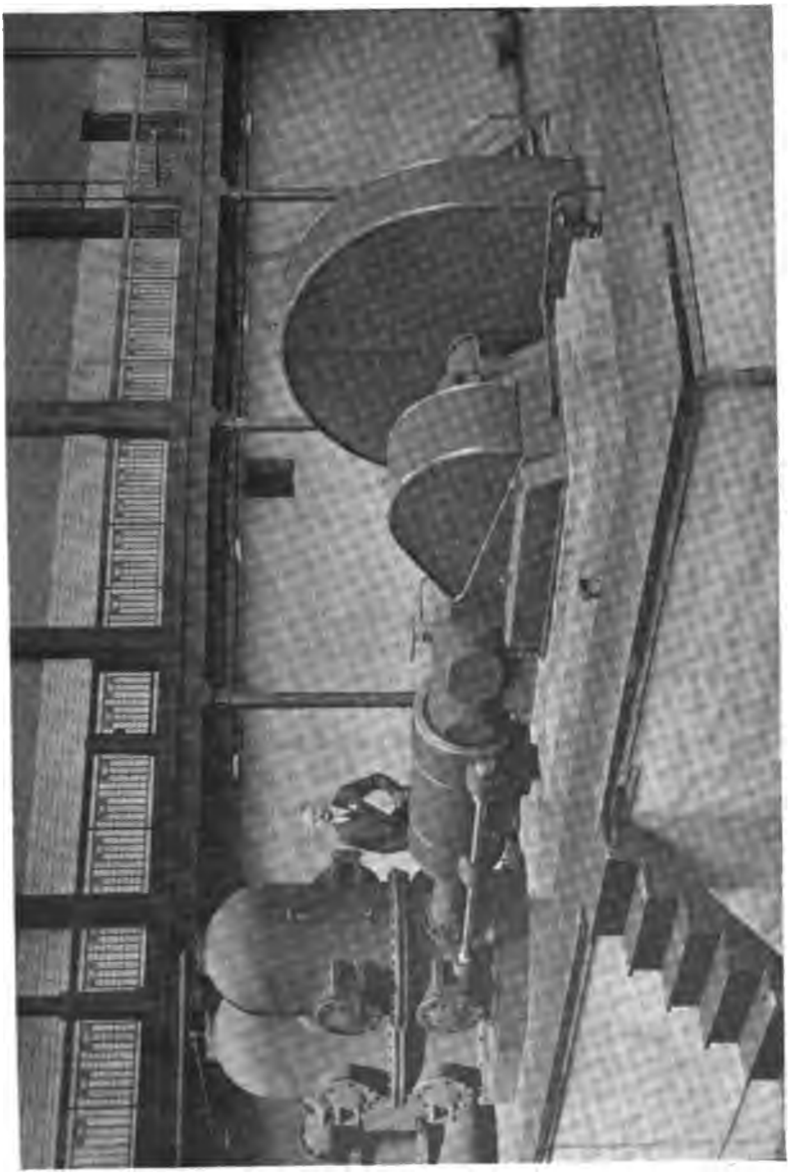
Tests for slippage. Water pressure, 35 lb. Plunger, single acting, 2 in. dia. by 12 in. stroke. Theoretical displacement, 1.361 lb. per revolution. Tests 1 to 9 made October 26; 10 to 16, October 30.

Test No.	Speed R.P.M.	Total Revs.	Plunger Displacement, Lb.	Total Lb. of Water Weighed.	Slip plus or minus.	Average Velocity through Valves. Feet per Second.
1	75	519	706.36	709	−4/10 of 1%	1.92
2	60	534	726.77	727		1.54
3	125	543	739.02	739		3.2
4	150	540	734.94	735		3.84
5	150	560	762.16	761	+2/10 of 1%	3.84
6	200	560	762.16	764	−2/10 of 1%	5.12
7	200	530	721.33	723	−2/10 of 1%	5.12
8	250	549	747.19	745	+3/10 of 1%	6.4
9	250	550	748.55	746	+4/10 of 1%	6.4
10	200	537	730.86	733	−3/10 of 1%	5.12
11	200	510	694.11	696	−3/10 of 1%	5.12
12	290	470	639.67	645	−8/10 of 1%	7.42
13	290	530	721.33	727	−8/10 of 1%	7.42
14	290	490	666.89	671	−6/10 of 1%	7.42
15	250	550	748.55	748	+1/10 of 1%	6.4
16	250	530	721.33	722	−1/10 of 1%	6.4

NOTE. Plus slip indicates that plunger displacement is more than actual water pumped.

Minus slip indicates that plunger displacement is less than actual water pumped.

The scales for weighing the water were tested and found to be correct.



When operating at 290 r.p.m. the valve opened $\frac{3}{16}$ in., the amount of opening was determined from the sound of the valve disk tapping the valve guard. At all other speeds the valves were noiseless in operation. These tests were very carefully conducted.

In developing a pump end the "unaflow" principle, in so far as it would apply to a pump, was given due consideration. This pump cylinder is of the general design shown by Fig. 1.

The tests of the 3 000 000 gal. pumping unit above described have been delayed and are not entirely completed. The working conditions for which the engine was designed have not yet been obtainable. For instance, instead of 100 degrees superheat steam it has been found that less than one tenth of this superheat was actually available, and no tests have yet been made with steam superheated to any extent. An independent superheater has been secured and is now being installed which will permit the making of tests with varying degrees of superheat, from 10° to 200° F.

One test for steam consumption has been completed, with approximately 200 lb. steam pressure, 95 lb. water pressure, 10 degrees superheat, 27.2 in. vacuum, 203 r.p.m., the resultant steam consumption per indicated horse-power hour being approximately 12.4 lb. as compared with 11.9 lb. of steam per indicated horse-power hour that the perfect Unaflow steam engine with 27 in. vacuum is supposed to develop under these conditions; the resultant duty was something under 140 000 000 foot-pounds.

A short slip test with calibrated nozzles was made at speeds ranging from 100 to 202 r.p.m., the percentage of slip decreasing at a uniform rate as the speed of the pump increased so that the apparent per cent. of slip at 200 r.p.m. was less than two thirds of the apparent slip at 100 r.p.m.

Both of these tests were made hurriedly in the endeavor to secure the data to present at this meeting. The results given are substantially correct; but further tests are being made and shortly we expect to know exactly what may be expected from this type of engine as to economy and general efficiency, under various conditions of service.

Discussion.

Mr. Harry Gardner. Did you say that no higher efficiency has been developed than in the ordinary engine?

Mr. Decrow. When we built this first engine, as far as the steam end was concerned we had to accept the contention of the licensees as to the economy of steam consumption. We are working now to find out what it is. They claim under the conditions we have operated that with a perfect Unaflow Engine we should get 11.9 lb. of steam per indicated horse power per hour, or with 235 lb. of steam and 100 degrees superheat the engine should give an indicated horse power per hour with 10 lb. of steam. We have obtained 95½ per cent. of the licensee's claim on the first trial. We are now trying to see if we cannot get it closer. It takes time, however, to do these things.

Mr. A. P. Folwell. Did you state what the slip was?

Mr. Decrow. There has been only one test for slippage made on this particular machine, and the water was measured by calibrated nozzles furnished by the New England Underwriters Association. I assume the figures were substantially correct. They showed about 4 per cent. slip; but we expect to reduce this to less than 1 per cent.

Mr. William F. Sullivan. In a general way, as a general proposition, what is the prospect of saving on this type of engine, and also of general use?

Mr. Decrow. It is going to cost considerably less than the cross compound, and we expect about the same or better results. There will not be any particular saving in the pump end because for a given quantity it has to have so much water passage anyway, but on the steam end we expect to save a good deal. I would say that the probable cost of it would be about 70 per cent. of the cost of a cross compound of the same capacity.

Mr. Edward D. Eldredge. Do you attach considerable importance to the discharge of the moisture in the cylinder into the exhaust at the end of the stroke?

Mr. Decrow. Oh, yes. We used to have reheaters in the receivers between the steam cylinders of our compound and vertical triple expansion engines, to re-evaporate any moisture, but

we found from actual experience that they were a detriment rather than a benefit, on the general theory, I presume, that no conversion is 100 per cent. perfect or 100 per cent. efficient. We do get rid, however, of any moisture formed as soon as possible.

MR. CHARLES W. SHERMAN. I should like to inquire about the room taken up by this machine.

MR. DECROW. That measures about 30 ft. long, and it is about 4 ft. wide, except at the flywheel.

MR. SHERMAN. You compared it in efficiency with the compound. Is it less in space occupied?

MR. DECROW. In space?

MR. SHERMAN. Yes. How does it compare?

MR. DECROW. The three million horizontal cross compound would probably be 12 ft. wide.

MR. SHERMAN. About the same length?

MR. DECROW. Well, it would be about 27 or 28 ft. long.

MR. SHERMAN. I presume it requires a flywheel?

MR. DECROW. Yes. The flywheel and moving parts are cased in. We did that on the general principle that if you are riding in an automobile you do not care what speed the engine is running at as long as it runs all right and you do not see or hear it. Water-works men, particularly the older engineers, do not care to see things run very fast.

MR. ELDREDGE. Do the piston rings pass the ports properly?

MR. DECROW. Yes. There is no trouble with that at all. The ports are circular holes around the cylinder.

THE SUPERVISION OF PUBLIC WATER SUPPLIES BY THE NEW YORK STATE DEPARTMENT OF HEALTH.

BY THEODORE HORTON, CHIEF ENGINEER.

The supervision of public water supplies by state boards and departments of health is, quite naturally, somewhat limited in scope though very important in character. It is limited in scope for the reason that the engineering and laboratory divisions of these health departments, whose resources are dependent upon legislative appropriations, have many functions to perform besides those relating to public water supplies. It is important in character because it is life saving in its purpose; and we must all concede that no purpose could be of much greater importance.

The authority which is exercised by the various states over public water supplies varies considerably. In some states this authority is lodged almost exclusively in the state board or department of health, which has supervision over questions not only of sanitary quality, but of yield, capacity, and distribution. In other states this authority is shared, through a somewhat sharp division of powers and duties, with some other state department, such as a water supply commission, or a conservation commission.

In the state of New York the supervision over public water supplies is exercised jointly by the state Department of Health and the state Conservation Commission. Although these two departments have, by statute, powers which somewhat overlap, in practice they work in close coöperation, and by mutual recognition each department performs separate and independent functions. The Health Department limits its jurisdiction and activities almost exclusively to engineering and laboratory questions pertaining to the sanitary quality of water supplies. The Conservation Commission limits *its* jurisdiction almost exclusively to legal and engineering questions of yield and distribution, including the

examination of plans for water-supply systems, authorization of bond issues, and the granting of permits for the use of the waters of the state for water-supply purposes. It is the supervision of the sanitary quality of these supplies to which the speaker will confine his remarks, for it is this work which the Engineering Division of the state Department of Health has been engaged in, during the past thirteen years.

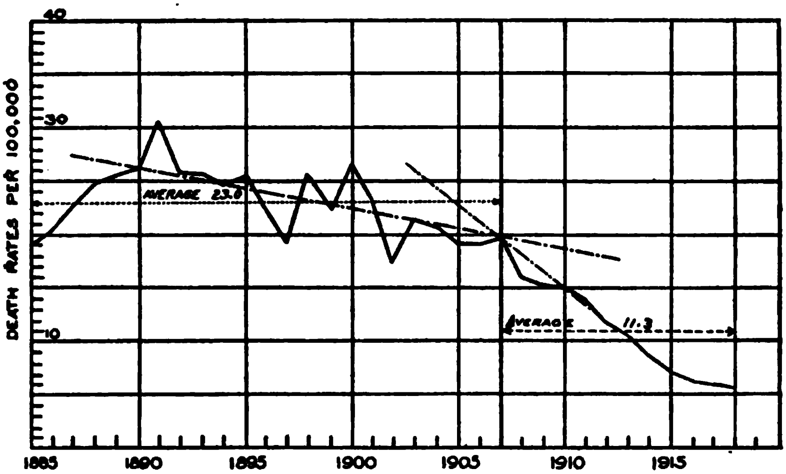
The Engineering Division was established in 1906, soon after the old state Board of Health was reorganized into a state Department of Health, with some five divisions or bureaus, of which the Engineering Division is one. When first established, the division staff comprised the chief engineer, one full-time assistant engineer, one part-time assistant engineer, and one part-time stenographer. The chief engineer's office was a corner of the health commissioner's conference table, when that was not in use. To-day, the regular divisional staff consists of twelve full-time engineers and five stenographers, with additional part-time employees for special investigation work. Incidentally, it should be kept in mind, the Engineering Division has many other duties besides those relating to water supplies, including examination and approval of plans for sewerage and sewage disposal, the abatement of important nuisances, supervision of milk pasteurization, and investigation and advice relating to stream pollution, garbage disposal, drainage, and other sanitary subjects. The work in connection with water supplies is, however, considered the most important, and approximately one half of the engineering force is employed almost exclusively upon it.

Before describing the character of our work in connection with water supplies, I wish to present a chart showing the typhoid fever rate in the state for the past thirty-five years. As you all know, the typhoid fever rate is one of the best indices of the sanitary conditions of any locality, and this curve for the state of New York is both interesting and instructive to those interested in epidemiology — particularly in relation to public water supplies. The chart is almost self-explanatory in regard to its construction; that is, abcissæ represent years from 1885 to 1918 inclusive, and ordinates the typhoid fever death rates, per hundred thousand of population. A glance at the chart shows that it may be divided

into two general periods, one prior to about 1907, and the other subsequent thereto. The characteristics of the earlier period are:

1. The rates for nearly the entire period are excessive, averaging approximately 23.1.

2. There is a marked lack of uniformity, the curve ascending and descending with considerable irregularity.



TYPHOID FEVER DEATH RATES IN NEW YORK STATE SINCE 1885
NEW YORK STATE DEPARTMENT OF HEALTH
THEODORE HORTON
Chief Engineer

3. The range of deviation from the mean is excessive, the curve ascending to a point above 30, in one instance, and below 18, in another.

In contrast with this part of the curve, note the character of the curve for the second period subsequent to 1907, and you will observe:

1. The rates are moderate, averaging for the entire period 11.3, and reaching the low point of 5.4 at the end of the period in 1918.

2. The curve is uniform in character, progressively descending, with only slight deviation at any point from the general direction.

3. The yearly rate of change at the latter end of this period is very much less than the rate of change at the beginning of the period; indicating that the limit of reduction of mortality from typhoid fever in the state has begun to be reached.

Now the question which naturally arises, after glancing over this curve is: What influence or changes in condition began to be exerted at the beginning of the later period, ranging from 1906 to 1919, that might rationally account for the subsequent rapid and uniformly downward trend of this curve, and the comparatively very low rate reached in the year 1918?

The answer, it seems to me, is largely in the fact, already stated to you, that in 1906, following a reorganization of the old state board into a state Department of Health, a new force or agency was added to the resources of the department, in the nature of an engineering division, one of whose specific duties was the investigation and supervision of public water supplies. Prior to the establishment of the Engineering Division, comparatively little attention, and no systematic activities, were directed toward the improvement of public water supplies in the state. Many of these water supplies had already been introduced, but up to that time the close relationship between the quality of public water supplies and typhoid fever incidence, seemed not to have been fully realized by the communities of this state generally, nor were the principles of the art of water purification and sewage disposal well understood. This fact is somewhat startling when we consider that this knowledge and relationship were well recognized by sanitarians, and by some state health authorities, as for instance in Massachusetts, where public water supplies were under excellent supervision, and were generally of good quality, and where the typhoid fever rate in the state was much lower than in this state. It is of particular interest to note, however, that almost simultaneously with this extension of the organization and scope of the New York State Department of Health at this time, and especially the establishment of the Engineering Division, equipped with scientific knowledge and facilities for systematically studying and investigating public water supplies, we find a very marked increase in public interest concerning the sanitary quality of public water supplies. This was clearly evidenced by a general demand for investigations; by a pronounced willingness by municipalities to heed advice; and by an almost immediate decline in the typhoid fever rates throughout the state — a decline that has uninterruptedly continued up to the present time.

Very naturally one may inquire at this point as to how we know that this decrease in typhoid fever is due to water-borne infection and not to other causes. No better answer can perhaps be given than by referring you to the accompanying table, showing what has actually occurred in the cities of the state with reference to typhoid fever, as a result of introducing water purification plants and other sanitary improvements. The table explains itself; and if you will glance down the list you will readily see that, in nearly every instance, the rates have dropped almost immediately following the introduction of these improvements. It is of course conceded — and the fact should never be overlooked — that typhoid fever is often traceable to other causes than infected water, as, for instance, infected foods, fly transmission, contact infection, and disease carriers. At the same time we must not overlook the fact that when typhoid fever occurs from so-called "residual" causes, it appears generally in the nature of epidemics, readily traceable, except perhaps in the case of "carriers." Nor again must we overlook that in most communities, at least in this latitude, supplied with *pure* water, the typhoid fever rates are generally low, and rarely over 10 per 100 000 — and less, of course, according to the freedom of these communities from infection due to so-called "residual causes." When, then, we are considering persistent and uniformly high rates, as 30, or 50, or even 100 per 100 000, as in the case of Niagara Falls and Albany, before these water supplies were improved, we can feel reasonably certain that we are dealing almost entirely with water-borne typhoid.

Finally, one has only to glance at such a table as this to be convinced that by no possible coincidence could any other reason than the purification or other improvement of the water supply be responsible for the marked reductions in the typhoid fever rates of these cities. In fact, out of the entire list there are only a few cities where it may be said that an improvement in the quality of the water supply has *not* been followed by a marked lowering in the typhoid fever rate. In these few cases either the original rates were not excessive before the introduction of water purification or the absence of the lowering of the typhoid rate has been due to special reasons, such as to inefficient operation of purification plants or to epidemics due to other causes, such as milk infection, typhoid carriers, etc.

Beginning with the year 1906, the Engineering Division started a series of special investigations of certain public water supplies, selected with special reference to high incidence of typhoid fever. A year or two later these special investigations were made a part of the routine work of the division, The yearly returns from this work, in terms of lowered typhoid fever rates, so clearly demonstrated its value that in each succeeding year more attention was given to this part of our work. It remained, however, for our present commissioner, Dr. Hermann M. Biggs, to fully appreciate the great value of this sort of life-saving work, and to foresee in it a great opportunity for lowering the general death rate of the state. In fact, almost immediately upon assuming office, Dr. Biggs directed that the principal work of the Engineering Division should be the investigation and supervision of public water supplies, and that this work should be prosecuted until all of the water supplies in the state shall have been investigated and improved, and the mortality rate from this source reduced to a minimum. It is needless to say that this policy is still in force; and the present low typhoid rate indicates that these aims of our commissioner have already been largely realized.

Although the speaker hesitates to burden you with statistical information, he wishes to state briefly, however, a few figures showing the progress that has been made during the past twelve years in the development and improvement of public water supplies in the state. In 1906 there were, in round numbers, some 400 public water supplies in the state, serving a population of about 6 100 000 persons. Of these supplies about 50, serving a population of 700 000, received some sort of treatment, either by slow sand or mechanical filtration. In 1919 there are approximately 530 public water supplies in the state, serving a population of approximately 8 500 000. Of these supplies about 130, serving a population of approximately 6 900 000, are treated either by filtration or chlorination. This means that in the thirteen years, from 1906 to 1919, the number of people supplied with public water supplies had increased from 6 100 000 to 8 500 000, or approximately 40 per cent.; while in the same period the number of people protected by water purification, in some form, had increased from 700 000 to 6 900 000, or an increase of almost 1 000 per cent.

Time will not permit of entering into *much* detail as to the methods employed in the supervision of these 530 supplies. The nature of our work is, of course, based primarily upon the provisions of the public health law. These provisions specifically authorize the state commissioner of health to enact and enforce rules and regulations for the protection of the watersheds of these supplies, and, generally, authorize him to investigate and report upon all of the water supplies of the state. At the present time about 80 out of the 330 surface water supplies of the state are protected by rules and regulations. Generally speaking, these rules and regulations are in the nature of prohibitions or restrictions against the pollution of reservoirs and water courses from various sources of polluting materials, such as privies, cesspools, sewers, barnyards, etc. These sets of rules and regulations are individual in character, vary with the different municipalities, and are enacted only after a careful inspection has been made of the watershed, and the specific requirements in each case determined. The enforcement of the rules involves action by the state and local authorities having jurisdiction. The procedure for abatement of violations is somewhat long, if not cumbersome, being designed to carefully protect riparian rights, and requiring that the *expense* of abatement shall be met by the municipality owning the supply — incidentally, a provision which has from a legal standpoint been the subject of much controversy.

It is the general investigations of the water supplies of the state, however, toward which the activities of the Engineering Division have been principally directed, for it is through these investigations and the advice and recommendations based upon them, that the most effective results have been accomplished. In an investigation of this kind, an assistant engineer is usually assigned to make a field inspection, which includes a sanitary survey of the watershed furnishing the source of supply, and an inspection of such physical features as pumping stations, distributing reservoirs, filter plants, etc. During this field inspection, statistical information is also obtained of the history and development of the water system, and of certain engineering data such as yields, capacities, storage, water consumption, and operating rates of pumps and filters. Bacteriological and chemical samples of

water are also collected of the source or sources of supply, of the raw and filtered water, in case of purification plants, and at such other points as may be necessary, — these samples being sent to the Division of Laboratories at Albany for analysis. Upon the completion of the field inspection a careful study is made in the office of the results obtained in the field, and of the laboratory analyses.

These studies are finally incorporated into a full report which has three essential features: first, a description of the physical character of the sources and distribution works; second, a discussion of the sanitary condition of the watershed, and the sanitary quality of the water; and third, our conclusions and recommendations, based upon the results of our studies. This report is duly transmitted to the local water board or company, the local board of health, and the sanitary supervisor of the district, who coöperate in the final part of the program, namely, a follow-up campaign for the purpose of stimulating public sentiment and the interest of the local authorities in having the recommendations in the report carried out.

Practically all of the 530 public water supplies in the state have been thus fully investigated and reported upon, and a large majority of them reinvestigated one or more times. The information contained in these reports is, of course, a great asset to the department, and particularly to the Engineering Division; for these reports form a complete system of records which are valuable not only for comparative future studies, but as a basis for concentration of efforts upon those supplies where improvements are needed.

As a part of the records kept of these supplies I should perhaps mention the application of the scoring system which has been developed by the writer and one of his assistant engineers, Mr. E. S. Chase. This system was carefully described in a paper presented to the Sanitary Engineering Section of the American Public Health Association in 1916. The score is on the percentage basis, and involves a combination of factors including the sanitary conditions on the watershed, the extent of water purification, and the efficacy of the measures of prevention and correction of pollution as indicated by laboratory analyses. Such a score system is valu-

	Before Im... in Water
...alled 1908. Hy-	1889- 88
...olluted streams	1898- 28
Liquid chlorine	1898- 20
	1898- 30
	1913- 9
	1889- 5
	1901-
....	

able for comparative purposes, stimulates a rivalry among municipalities for improvements, and enables the division to know at a glance which are the good, the bad, and the indifferent supplies, — incidentally which ones should be the subject of our attack for the purpose of improvement.

In addition to these investigations and other routine duties connected with water supplies, there are, as might be assumed, other phases of the work of a special or miscellaneous nature. One of these is the preliminary advice and final approval of water supplies of various state institutions and county tuberculosis hospitals, of which there are more than 100, some with populations of 5 000 or over. Another is the investigation of water supplies of private institutions and individuals where for special reasons these are authorized. Still another, and perhaps one of particular importance, is the emergency disinfection of a supply when it has been deemed to be the source of an impending or actual epidemic of typhoid fever. This last phase of the work has been carefully developed and has been found to be highly effective. The Engineering Division maintains an emergency chlorination plant which is always ready for immediate installation whenever the call comes. It has been used in a number of instances during actual epidemics, and in every case the epidemic has been immediately checked.

The speaker would be disappointed, indeed, if he left an unqualified impression that the general improvement in the sanitary quality of water supplies of the state, and the resultant marked reduction in typhoid fever mortality in the state were due *solely* to the efforts of the Engineering Division of the State Department of Health. That its efforts have constituted a primary force in the accomplishment of these ends will be clear to any one who cares to study the local history and chronology of these improvements in connection with our investigations and reports. Alone, the work of the Engineering Division would have accomplished little; in fact, would have been largely ineffectual, without the coöperation of other agencies such as the sanitary supervisors, local health officers, and particularly the superintendents and officials of local water boards and water companies, whose assistance in the field has been both necessary and invaluable.

PROCEEDINGS.

November Meeting.

Hotel Brunswick,
Boston, November 12, 1919.

Mr. Samuel E. Killam, President, presiding.
The following members and guests were present:

Honorary Members.

E. C. Brooks. F. E. Hall. R. J. Thomas. — 3.

Members.

L. M. Bancroft.
C. R. Barker.
A. E. Blackmer.
J. W. Blackmer.
Bertram Brewer.
Eugene Carpenter.
J. S. Caldwell.
R. D. Chase.
W. R. Conard.
J. E. Conley.
F. L. Cole.
F. A. Darling.
J. H. Dillon.
A. O. Doane.
A. W. Dudley.
E. D. Eldredge.
F. L. Fuller.
C. B. Garmon.
Patrick Gear.
F. J. Gifford.
T. W. Good.
H. J. Goodale.
F. W. Green.
F. M. Griswold.
I. H. Henderson.
D. A. Heffernan.
G. A. Johnson.
J. M. Jones.
Willard Kent.
S. E. Killam.
A. C. King.
G. A. King.
F. H. Luce.
D. B. McCarthy.
F. A. McInnes.
Hugh McLean.
H. V. Macksey.
J. H. Mendell.
Morrison Merrill.
Leonard Metcalf.
H. A. Miller.
M. L. Miller.
William Naylor.
F. L. Northrop.
H. E. Perry.
H. F. Salmonde.
P. R. Sanders.
C. W. Sherman.
Sidney Smith.
G. H. Snell.
R. H. Stearns.
H. A. Symonds.
D. N. Tower.
W. A. Tripp.
R. S. Weston.
F. I. Winslow.
M. B. Wright. — 57.

ASSOCIATES.

Bond, H. L. Co., by F. M. Bates.
Builders Iron Foundry, by A. B. Coulters.
Byers, A. M. Co., by H. F. Fiske.
Central Foundry Co., by R. W. Conrow.
Fire & Water Engineering, by R. H. Lockwood.
Goulds Mfg. Co., by C. W. Fulton and H. F. Miller.
Hayes Pump & Machinery Co., by F. H. Hayes.
Hersey Mfg. Co., by J. H. Smith.
Leadite Company, The, by George McKay, Jr.
Lead Lined Iron Pipe Co., by T. E. Dwyer.
Ludlow Valve Mfg. Co., The, by A. R. Taylor.
National Meter Co., by J. G. Lufkin and M. L. Miller.
National Tube Co., by H. T. Miller.
National Water Main Cleaning Co., by B. B. Hodgman.
Neptune Meter Co., by D. B. McCarthy and W. H. McGarry.
Pittsburgh Meter Co., by G. C. Northrop.
Power Equipment Co., by E. F. Leger.
Rensselaer Valve Co., by C. L. Brown and I. A. Rowe.
Smith, A. P. Mfg. Co., by F. L. Northrop.
Thomson Meter Co., by E. M. Shedd.
N. Y. Continental Jewell Filtration Co., by A. M. Crane.
Union Water Meter Co., by D. K. Otis and H. W. Jacobs.
Warren Foundry & Machine Co., by H. H. Kinsey.
Wood, R. D. & Co., by R. M. Simon.
Worthington Pump & Machinery Corp., by Samuel Harrison.
Gamon Meter Co., by R. J. Thomas. — 31.

GUESTS.

MASSACHUSETTS.

Boston, Dr. P. E. Gear, J. B. McNamee, and Prof. W. H. Walker.
Winchester, H. W. Dotten.

NEW YORK.

Charles A. Whitney. — 5.

The Secretary presented applications for membership from C. P. Hsueh, New York City, draftsman New York Central Railroad Co.; G. G. Hare, city engineer, St. John, N. B.; George A. Adams, Dedham, Mass., superintendent Needham Water Department; George E. Ahern, Arlington, Mass., superintendent public works; Osgood N. Mayhew, Oak Bluffs, Mass., superintendent Cottage City Water Company; Albert C. Roberts, Lakeville, Conn., manager and treasurer, Lakeville Water Company; George E. Russell, Arlington Heights, Mass., assistant professor of hydraulic engineering, Massachusetts Institute of Technology;

John F. Lucey, Somersworth, N. H.; Harold S. Palmer, Trinity College, Hartford, Conn., Ground Water Division, U. S. Geological Survey in Connecticut and Idaho; Charles A. Holden, Hanover, N. H., director of the Thayer School, professor of civil engineering, Dartmouth College, — ten applications all properly endorsed and recommended by the Executive Committee. All were duly elected.

The Chicago Meeting of the Engineering Council.

The Secretary read a communication* from Langdon Pearse, delegate to the meeting of the Engineering Council, held in Chicago, April 23–25, 1919.

Department of Public Works.

The Secretary read the following report of the committee to which was referred Senate Bill 2232, entitled " A Bill to Create a Department of Public Works," etc.:

Woburn, Mass., November 3, 1919.

The Committee to which was referred Senate Bill 2232, entitled " A Bill to Create a Department of Public Works and to Define its Duties," having considered same, begs leave to submit the following report:

Whereas: The New England Water Works Association has through its Executive Committee, and also through a special committee appointed for that purpose, considered Senate Bill No. 2232, presented at the first session of the sixty-sixth Congress, entitled " A Bill to Create a Department of Public Works, and to Define its Powers and Duties." Therefore be it

Resolved: That the New England Water Works Association firmly believes that such a department is necessary, and that the said bill is in general principles a wise measure, and that it recommends that its members individually give all the assistance that they can towards the final passage of the bill.

Be It Further Resolved: That a copy of this vote be forwarded to the Engineers, Architects, and Constructors Conference on National Public Works.

For the Committee,

H. V. Macksey,
Chairman.

The report was accepted and resolutions adopted.

* On file at office of New England Water Works Association.

The Secretary also read a communication from James Jackson, division manager of the Red Cross, calling attention to the Red Cross campaign for membership.

Prof. William H. Walker, of the Massachusetts Institute of Technology, presented a paper on "The Prevention and Cure of the Red Water Plague."

The discussion was participated in by Mr. Frank W. Green, Col. George A. Johnson, and Mr. Robert Spurr Weston.

Mr. Creed W. Fulton, New England manager of The Goulds Manufacturing Company, Boston, read a paper, illustrated by stereopticon views, on "Modern Pumps for Small Water Works."

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., November 12, 1919, at 11 A.M.

Present, President Samuel E. Killam and members Henry V. Macksey, Charles W. Sherman, Percy R. Sanders, James H. Mendell, Frank J. Gifford, Patrick Gear, Henry A. Symonds, Lewis M. Bancroft, and Willard Kent.

Ten applications for active membership were received, viz., George A. Adams, superintendent water works, Needham, Mass.; George E. Ahern, superintendent public works, Arlington, Mass.; G. G. Hare, city engineer, St. John, N. B.; Charles A. Holden, director of Thayer School of Civil Engineering, Hanover, N. H.; C. P. Hsueh, New York, N. Y.; John F. Lucey, superintendent water works, Somersworth, N. H.; Osgood N. Mayhew, superintendent Cottage City Water Company, Oak Bluffs, Mass.; Harold S. Palmer, professor of geology, Trinity College, Hartford, Conn.; Albert C. Roberts, manager and treasurer of the Lakeville Water Company, Lakeville, Conn.; George E. Russell, associate professor of hydraulic engineering, Mass. Institute of Technology, Cambridge, Mass.; and they were by unanimous vote recommended therefor.

The report of the committee on memoir of John Mayo, of Bridgewater, Mass., was received and ordered printed in the JOURNAL of the Association.

The death of Irving S. Wood, of Providence, R. I., a member of the Association since March 8, 1905, who died the 20th ult., was announced and the President was authorized to appoint a committee on memoir.

A communication from the Red Cross Association was presented and ordered read at the meeting of the Association.

The report of Mr. Langdon Pearse, representative of the New England Water Works Association to the Chicago meeting of the

Engineering Council, was presented, together with the report of the Committee on "Senate Bill No. 2232, To Create a Department of Public Works and Define Its Powers and Duties," and they were ordered submitted to the meeting of the Association.

On motion of Mr. Macksey, it was voted: That, as a general rule, subject to the discretion of the Editor, galley proofs shall not be submitted to the authors for correction.

After discussion of the subject of the substitution of bond for certified check with proposals for furnishing water-works material, the President was authorized to appoint a committee on the subject, to report at the annual meeting of the Association.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

REPORT OF COMMITTEE ON BUDGET FOR 1920.

[Read at December 10, 1919, meeting.]

To the Members of the New England
Water Works Association:

Gentlemen, — The committee appointed " to make a study of the finances of the Association and report on a budget system for 1920 " submits the following report:

The income of the Association may be classified under four heads: first, moneys received from membership dues and fees; second, moneys from advertisers in the Journal and subscriptions to and sales of the same; third, dividends and interest on invested funds; and fourth, miscellaneous receipts made up largely from the sale of dinner tickets.

From the present membership (July, 1919) of 797 members and 72 associates, we may expect to receive a total income of $4 628. The income from the Journal has averaged, for the last nine years, $2 265 per year, and your committee places the approximate income from this source at $2 250.

Dividends and interest have averaged $203 annually, and we have estimated this income as $200.

The income from miscellaneous sources has averaged about $968 per year, and we have called it $950, thus making the total annual receipts $8 028.

It has seemed unwise to estimate moneys received from initiation fees, as these are so variable, and they have been omitted as a source of positive income. In 1916 we received from fees $682, but in 1918 the amount was only $97.

In December, 1917, the dues of members were raised from $3 to $4, and of associate members from $15 to $20. Had the membership of the Association remained the same as it then was, namely, 901 members and 87 associates, the income would have been $716 more per year than on the basis of the membership of

July 1, 1919, which are the membership figures your committee has been obliged to use in estimating the present income of the Association.

That this loss in membership cannot be due wholly to the raising of the dues is shown by the fact that the Association lost 41 members the year previous to that in which the dues were raised as against 86 lost the year they were raised. The year previous to the raising of the dues the Association gained 3 associate members, while the next year saw a loss of 10 associates and last year it lost 5 more.

The present approximate expenditures of the Association may be classified as follows:

Office expenses:

Salary of Secretary	$200.00
Salary of Assistant to Secretary	1 080.00
Rent	550.00
Membership lists	300.00
Expenses of Secretary	50.00
Expenses of Assistant to Secretary	150.00
Printing, stationery, and postage (average for seven years, $301)	300.00
	$2 630.00

The "office expenses" of the nine years 1910–1918 have averaged $2 074 per year.

Expenses of meetings and committees:

Stereopticon (average, $55)	$75.00
Dinners and incidentals connected therewith	900.00
Printing, stationery, and postage	300.00
Treasurer's salary and bond	70.00
Incidental expenses	200.00
	$1 545.00

Average for nine years, $1 800.

After a careful study of the receipts and expenditures of the Association, the committee recommends the following:

BUDGET FOR 1920.

Salary of Secretary	$200.00
Salary of Assistant to Secretary	1 080.00
Rent	550.00
Printing of membership lists	300.00
Expenses of Secretary and Assistant to Secretary	130.00
Printing, stationery, and postage	400.00
Dinners and incidentals connected therewith	900.00
Treasurer's salary and bond	70.00
Incidental expenses	270.00
	$3 900.00
For publication of the JOURNAL	4 100.00
Total	$8 000.00
Estimated receipts	$8 028.00

The reduction in expenses of Secretary and Assistant to Secretary have been made by the committee not as a criticism of present methods but in the belief that if it is necessary to practice strict economy in all departments of the Association it will be feasible for these expenses to be reduced as well.

The committee feels that a material reduction can be made in the cost of printing and stationery by discontinuing the practice of furnishing special letterheads for each officer and each member of a committee of the Association. It recommends that one standard form of letterhead be printed, containing the name of the Association but excluding the list of officers and committees, and, similarly, for stamped envelopes, in order that the one form may be suitable for any one connected with the Association, and for one year as well as another. It also recommends that as far as possible the printing of letterheads and stamped envelopes be done by one printing concern in sufficient amount to furnish letterheads and envelopes for at least six months' supply, and, if conditions warrant, for one year's supply. The committee believes that still further economy can be had by changing the form of meeting

announcements to a sheet printed on one side only and by eliminating all matter which may not be strictly necessary.

The committee does not wish to criticize the practice of having special letterheads or the present form of meeting announcements. All of these features are attractive, if the finances of the Association warrant the expense. In this case, however, it seems apparent that with present high prices, the strictest economy must be practiced if the expenses are to be kept within the present income.

As the increasing cost of printing the JOURNAL is one of the most serious items of expense which the Association is called upon to meet at the present time, the committee recommends that all but the most essential portions of the proceedings valuable for future reference be eliminated. The material printed might include the annual reports of the Secretary, Treasurer, and Editor, the names of new members elected to the Association, and possibly certain important motions passed by the Association.

The committee further recommends the Secretary be directed to keep a loose-leaf, typewritten record book constituting the official record of the proceedings of the Association, which shall be written out in full and shall contain all data as at present recorded. This record book should be kept on file at Association rooms, where it can be consulted by the proper persons.

As it often happens that in papers read before the Association there may be some matters of transient interest only, the committee recommends, as an additional means of bringing the expenses of printing within the appropriation allowed for the JOURNAL, that the Board of Editors be requested to consider the feasibility of omitting from publication such portions of papers presented as said board may deem expedient and wise.

Your committee would call attention to the fact that there will be no value in the establishment of a budget system unless it is made the business of some one to see that the expenditures are kept within the several amounts appropriated. In order that this may be accomplished, the committee recommends that the Executive Committee be directed not to exceed the several expenditures authorized in the budget without a vote of the Association.

For the purpose of keeping the Executive Committee in close

touch with the financial condition of the Association, the committee recommends that the Secretary and the Treasurer be required to furnish to the Executive Committee a monthly statement of receipts and expenditures, classified in such a way that the said committee may be able to check up these expenditures against the budget.

The loss of 145 members and 12 associates since the maximum membership of 1 043 on January 1, 1917, indicates the necessity of making a drive for new members. In the three years of 1914, '15, and '16, the Association gained 256 members and 24 associates, and now that the war is over and affairs are more nearly normal it would seem entirely feasible to win back many of those members, who have resigned for one cause or another, and to add new members, thus bringing the membership of the Association back to and possibly above its maximum figure of 1 043.

In closing this report the committee would summarize its recommendations as follows:

The adoption of the budget presented:

That the Executive Committee be directed not to exceed the several expenditures authorized in the budget without a vote of the Association.

That the Secretary and Treasurer be directed to furnish the Executive Committee with a monthly statement of the receipts and expenditures, classified according to the items of the budget.

The adoption of a standard form of letterhead and envelope suitable for all official uses and unlimited as to time in which such stationery must be used.

That, so far as possible, the printing of all stationery be done by one concern and in quantity sufficient for at least one year's supply.

That, for the present, the announcements of meetings be made on a sheet printed on one side only, and that all matter not strictly necessary be eliminated from such announcements.

That in printing the JOURNAL all but the most essential portions of the proceedings be eliminated.

That the Secretary be directed to keep a loose-leaf, typewritten record book constituting the official record of the proceedings of

the Association, which shall be written out in full, and that this record book shall be kept on file at the Association rooms.

That the Board of Editors consider the feasibility of omitting from publication in the JOURNAL such portions of the papers presented before the Association as it may deem expedient and wise.

That the Association consider the advisability of a drive for new members.

Respectfully submitted,

GEO. A. CARPENTER.
EDWIN L. PRIDE.
FRANK A. MARSTON.

BOSTON, December 10, 1919.

JOHN MAYO.

John Mayo was born in Weston, Herefordshire, England, in 1859, and died at Bridgewater, Mass., August 21, 1919.

He settled in Bridgewater in 1880, and there married Martha Husbands, who with his two daughters, Annie M. Dorr and Sarah W. Mayo, survive him.

His first employment in Bridgewater was as a clerk in a market and he later engaged in a similar business on his own account.

In 1900 he was appointed superintendent of the Bridgewater Water Company, and in 1902 he was elected tax collector of the town of Bridgewater, both of which offices he retained until his death. His efficient conduct of both offices was highly satisfactory to his townspeople, and his books and records were models of neatness and accuracy.

For many years he was a regular attendant of the First Congregational Church (Unitarian) in Bridgewater, and was active in all matters pertaining to its welfare.

For twenty years he was secretary of Fellowship Lodge, A. F. & A. M., in his home town. He was for many years, also, treasurer of the board of trustees of Mt. Prospect Cemetery in Bridgewater. For thirty-six years Mr. Mayo was a member of the Bridgewater Fire Department, during many years of which period he was one of the fire engineers. He was especially interested in the electric fire-alarm system, and through his efforts the same was maintained with a high degree of efficiency.

He was a director of the Bridgewater Coöperative Bank and an incorporator of the Bridgewater Savings Bank.

He was elected a member of the New England Water Works Association in February, 1904.

In all his varied activities he displayed that same care and thoroughness and high sense of duty which characterized his whole

life. Quiet and unassuming in his manner, he was nevertheless a tireless worker in all matters for the benefit of his town.

His family life was unusually congenial, and in his church and fraternal affiliations his wise counsel and steadfast support were highly valued and will be greatly missed.

Arthur E. Blackmer, *Chairman*,
D. N. Tower,
A. C. Howes,
Horace Kingman,
Committee.

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New England Water Works Association.

1919.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 900 men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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An Oasis in the Blasted Argonne-Meuse Area.
A water point along the Avocourt-Montfaucon road, fed by pumping from a nearby spring.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXXIII. December, 1919. No. 4, Section 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

HISTORY OF THE 26TH ENGINEERS, U.S.A.

(WATER SUPPLY REGIMENT)

IN THE WORLD WAR, SEPTEMBER, 1917 — MARCH, 1919.

THE STORY OF THE REGIMENT.

This is a story of Service; of a regiment of men who sought "the Service," whose motto was "Service," and who gave their best service no matter what the job. A majority of the men came from civil occupations which had more or less to do with water, and in France the regiment formed the nucleus of the "Water Supply Service" of the American Forces. Thus its members may well have a feeling of satisfaction that they had opportunity to render the service for which they were best fitted, even if they could not literally "go over the top."

Finding the right place in the complex whirling machinery of a war-time army is a difficult matter, not only for individual men but occasionally for whole regiments. Not so with the 26th Engineers, however, for hardly had enough men been enrolled to make two companies before the call came from France for water-supply troops. From then until the American forces reached the Rhine, the regiment and even single companies were literally torn to pieces in the efforts of regional and army commanders to secure the specialized services of water-supply troops. Although at the temporary sacrifice of regimental spirit, this dispersion gave greater opportunity for service, broadening the view of officers and men from the horizon of regiment or division to that of army, and even to that of the entire Expeditionary Forces.

The experiences of the men, recounted among themselves while waiting as a regiment for transportation home, and read from the

pages of this brief history, cannot but cement them in a common fellowship of service which will more effectively preserve the "spirit of the 26th" than the memory of years of regimental military functions or months of active service as a unit in the army zone.

Due to the peculiar circumstances under which the 26th Engineers operated, this history consists of a series of accounts of the activities of each detachment and company of the regiment. Nevertheless there are certain facts, common to all, which deserve mention:

1. The regiment was almost entirely a volunteer organization, made up of skilled tradesmen and engineers drawn from practically every state in the Union.

2. The regiment furnished the first of the Engineer troops authorized for a field army to see service in France, and was among the first to be stationed for duty in the Zone of the Armies.

3. The regiment was organized to do the water-supply work of one field army. In actual fact, however, it not only saw much service in the area of the Services of Supply, but during the period of activity in the American Army zone it was divided among the three field armies of the American Expeditionary Forces.

4. Prior to the major operations at the front, the 26th Engineers constructed complete water-supply systems at 36 hospitals and permanent camps in the area of the Services of Supply and complete sewage systems at 14 hospitals in the same area.

5. Companies of the regiment served as army water-supply troops in each of the three major operations, — Aisne-Marne offensive, St. Mihiel offensive, and Argonne-Meuse offensive, — and also in the defense of the Toul and Baccarat sectors and during the march to Germany.

6. During the St. Mihiel and Argonne-Meuse offensives the regiment constructed and operated 125 temporary and 105 semi-permanent military "water points" for men and animals. It also operated approximately 100 existing French water points, and constructed 48 railway locomotive filling stations. A total length of 120 000 ft. of 2- and 4-in. pipe was laid in connection with this work. Whole companies served continuously within the range of enemy shell fire for periods of from fifty to ninety days, without relief or rest.

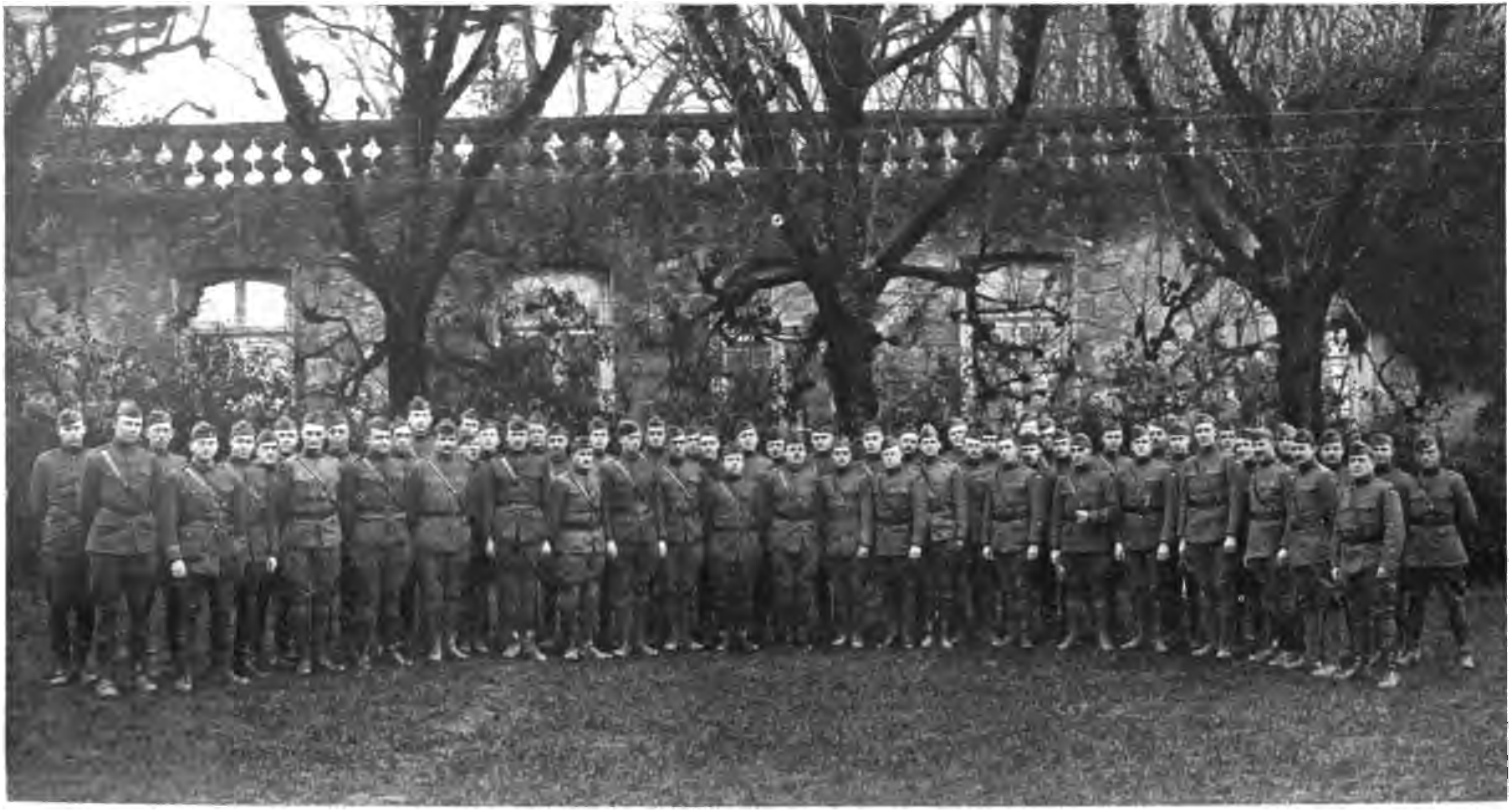
7. A detachment from the 26th Engineers was among the first American troops to reach Coblenz.

Need for Water-Supply Troops.

The important part which water supply bears to the successful execution of military operations has long been realized. Never before the World War, however, has specific provision been made, in technical personnel and materiel, for the supplying of adequate quantities of potable water to armies in the field. This innovation was not the result alone of the arid conditions under which it was attempted to carry on certain campaigns such as those of the British at Gallipoli and in Palestine and of the Italians in eastern Italy. An even more important reason was the inadequacy, and often the pollution, of local supplies in the humid regions of northern France, under the conditions of unusual troop concentration which has characterized operations on the Western Front.

Existing wells and developed springs were so inadequate in certain early operations on this front that the failure to attain success was directly ascribed to the lack of sufficient water for the troops and animals engaged. In other instances the use of polluted water resulted in sickness and lowering of morale among the troops. These experiences led to the organization, in the various Allied armies, of specialized troops with technically experienced personnel for water-supply service. That the Germans also realized the importance of water supply was amply shown by the extensive pipe-line systems, with pumping plants and reservoirs, which were found immediately behind their lines in France. Printed maps of various sectors were also found in captured dugouts, showing in detail a great variety of water-supply information within the German lines, for the use of troop commanders and officers whose duty it was to provide developed water where needed.

There was thus ample justification for the authorization and organization of a water-supply regiment for the American forces as provided by General Order No. 108, War Department, August 15, 1917.



OFFICERS, 26TH ENGINEERS, BOURG-SUR-GIRONDE, FRANCE, JANUARY, 1919.

ORGANIZATION.

The new regiment was designated as 26th Engineers, and Camp Dix, N. J., assigned as a mobilization camp. The first officers received orders to report not later than September 6, 1917. On September 10, Major E. H. Whitlock assumed temporary command, and Capt. Robert Boettger was designated regimental adjutant. Various other officers were assigned to regimental headquarters and to Companies A, B, and C. The first enlisted men arrived September 11, and from then on the growth of the regiment was rapid. A few days later, Col. E. J. Dent, Engineers, took command, and training commenced in real earnest.

Other than giving publicity to the organization in newspapers and engineering journals throughout the United States, very little effort was devoted to recruiting. The men came by voluntary enlistment in a steady stream, and one after another the companies were filled to strength. Company F was the last to be assembled, and obtained its full enlisted personnel June 15, 1918. There were weeks and months of steady training, but the life was new and the hope of " going over " soon was kept bright by seeing one after another of the companies " secretly " depart.

PERSONNEL.

The personnel of the regiment was probably drawn from as widely distributed an area as any regiment in the United States Army. Every state in the Union was represented excepting only Idaho and Arkansas, and even Alaska and the Panama Canal Zone had their representatives. Among the officers, New York claimed the lead with 28 per cent., while California followed with 6 per cent. Michigan furnished the greatest proportion of the enlisted men (17 per cent.), followed by California (14 per cent.), Pennsylvania (12 per cent.), and New York (8 per cent.).

The great majority of men in the regiment were skilled workmen or had had experience as engineers or on construction work. The oil-producing industry furnished more men (16 per cent.) than any other single industry, and was represented by a type of man peculiarly fitted for the work which the regiment was called upon to do in France. The automobile industry was also well

represented (13 per cent.), and supplied the truck drivers who, although working under great difficulties and often under shell fire, kept the many detachments at the front supplied with equipment, material, and rations. Most of the men were skilled tradesmen, the list including well drillers, truck drivers, plumbers, pipe fitters, mechanicians, carpenters, masons, brick layers, concrete men, blacksmiths, electricians, steam and gas engine men, pump operators, clerks, etc. There were also draftsmen, surveyors, engineers, and construction foremen. Among the officers, 50 per cent. had had practical experience in hydraulic engineering and construction, 25 per cent. in general engineering and construction, and the remainder in mechanical, electrical, and sanitary engineering.

The members of the regiment were characterized by enthusiasm and energy in the performance of their work. The spirit was maintained even among the three companies which after reaching France were engaged for a considerable period of time on work far to the rear of the line of actual fighting.

Early Work in France.

The work of the first three companies which reached France was intimately connected with the Services of Supply, or the S.O.S., as it was usually termed. This portion of the American Expeditionary Forces was responsible for the transportation of supplies and the handling of troops from the base ports up to the Zone of the Armies. For this purpose ample facilities were necessary, including docks, terminals, railways, storage depots, barracks, and hospitals. The crowded state of the ports and railways of northern France necessitated the use by American forces of the western and southern French ports, such as Brest, St. Nazaire, Bordeaux, and Marseilles, and a line of existing railway leading from the southwestern ports northeast through Tours and Châteauroux to Dijon, Langres, and finally to points near the American front.

The existing facilities at base ports and along the lines of communication, although freely made available by the French Government, were entirely inadequate for the needs of an American army of three or four million men. Many thousands of feet of new docks were required with appropriate freight handling equip-

ment and railway terminal facilities, while further inland several immense storage depots were necessary for the classification and handling of supplies and material which during the height of activities arrived at the rate of 45 000 tons daily. In addition, there were almost innumerable hospitals and camps of various kinds requiring the erection of buildings, construction of roads and railroads, and installation of public utilities.

The Engineers, whose duty it is to plan and construct all projects required in connection with military operations, were confronted with this enormous task in the late summer of 1917. At that time there were but few American engineers or labor troops in France, and every available organization was called upon for assistance.

Although the 26th Engineers was intended for service in the Zone of the Armies, it became necessary in the fall of 1917 to send two companies of the regiment to France to install water systems at these various projects. A few months later a third company was ordered overseas. Thus it was that Companies A and B, reënforced by the Specialist Detachment, and later Company C, were called upon to serve their apprenticeship in the S.O.S.

The "big idea" in the S.O.S. was to get something built, and in these early months it mattered little what an organization was best fitted to do, as long as the men had hands and feet. In addition to hands and feet, however, the men of the 26th Engineers had heads and a purpose to do their best, and whether it was building roads, digging pipe trenches, or placing pumps, pipe lines, and tanks, the work was done quickly and well.

As time went on, American activities at the front began in real earnest. Then it was that the spirit of these men of the first three companies was tried to the limit, for they not only saw newly arrived infantry and artillery organizations pass by on their way through the S.O.S. to the front, but even the "green" Companies of their own Regiment. The quality of their work did not change, however, and when the call from the front finally came, it was with great reluctance that the S.O.S. released them.

Work in the Army Zone.

The spring of 1918 found American divisions training in the army zone and, as part of French armies, occupying several sectors between Verdun and the Swiss border. The increased demand for water-supply facilities, as summer came on, made necessary the presence of American water-supply troops to assist the Service des Eaux of the Eighth French Army.

Company B was chosen for this duty, and on May 30, 1918, the delighted members of this organization found themselves within sight and sound of the "front," at Lagney in the Toul sector.

Two months later, Company D arrived in France and was ordered to the Aisne-Marne front, reaching Fere-en-Tardenois on August 9. Both companies soon received their baptism of shell fire and became "veterans."

The activities of Company B during this preliminary period were largely preparatory for the great attack soon to be launched. Sources of water, such as springs and wells, were sought out, and the necessary work done to protect them from pollution; small reservoirs were constructed; power pumps, pipe lines, and elevated tanks were installed at frequent intervals along the less important roads or near the principal highways at which company water carts or motor tank trucks could fill; and horse troughs were constructed at various places in the woods, with pumps and pipe lines to keep them supplied.

In the midst of this work came secret orders, on August 18, to prepare for a tremendous offensive on the Toul front, which would commence within twenty-five days. During the few days preceding the attack, the First Army staff proposed to place a maximum of 600 000 men and 190 000 horses behind the lines between the village of Xivray and Forêt de Facq, a distance of 22 miles. The Water Supply Service was called upon to furnish the necessary water for these troops and animals.

The local French officer of the Service des Eaux, who had drilled more than 30 wells in this sector in an unsuccessful effort to secure an abundance of pure water, when told of the plans of the Americans, exclaimed with characteristic French vehemence, "*Impossible! Impossible! Il n'y a pas suffisance d'eau.*" He had not

reckoned on the use of surface waters, however, and great was his astonishment when he first saw a water purification truck in operation. This apparatus could be rapidly moved from place to place, and within a very short space of time commence delivering a stream of clear, pure water from a muddy, polluted stream. The American water-supply troops made great use of these purification trucks throughout the period of activities in the army zone.

At the time these orders were received to prepare for the St. Mihiel attack, Company B was responsible for water supply in this sector. The efforts of the Company were redoubled, but the area was too great for one company and part of Company D was brought from the Aisne-Marne front. Also Company B and part of Company A, 27th Engineers, were brought in. Even this addition was insufficient, however, and the 37th Engineers was called upon to furnish a company to do water-supply work in the sector south of Verdun. The various details worked every daylight hour, and motor trucks hauling material and rations were often on the road all night. In this manner the work of preparation was carried on right up to the day of the attack.

The second period in the activities of the 26th Engineers in the army zone commenced with the opening of the St. Mihiel offensive on September 12. Companies E and F had just arrived fresh from the States, and much to the disgust of the "veterans" these companies were immediately sent to the front. The program for water-supply troops during an offensive differed from that of trench warfare. Parties made up of about three squads, with an escort wagon containing rations and pioneer water-supply equipment, were each assigned a sector of about two miles, and advanced as close to the active front as possible. These parties performed emergency and temporary work, cleaned out springs and wells, repaired and installed hand pumps, placed temporary horse troughs, placed canvas-lined reservoirs for receiving water brought forward by water-tank trucks, and made quick repairs to village water systems where they existed.

Following behind the pioneer parties were detachments with motor transportation which constructed semi-permanent water points where needed. The latter usually consisted of a power pump, pipe line, and elevated tank with a paved turnout from the

Hand pumps placed at cleaned-out springs and wells	48
Canvas reservoirs placed, and filled by water-tank train	31
Horse-watering troughs placed	19
Water-tank trucks operated	77
Average daily haulage by tank trucks	14 000 gal.
Water purification trucks operated	10
Water purification truck emplacements	47
Semi-permanent water points constructed (with power pump)	43
Semi-permanent water points constructed (gravity)	13
Average daily deliveries of water:	
Water purification trucks	70 000 gal.
Semi-permanent water points	480 000 gal.
Total (not including hand pumps)	550 000 gal.

The St. Mihiel and Argonne-Meuse operations gave the men of the 26th Engineers an unlimited opportunity to demonstrate their worth as army water-supply troops under combat conditions. Although there may have been defects in the hastily formed organization and shortage of equipment and material, yet these only served as a background to make more apparent the initiative and adaptability of the men and the speed and skill with which they worked. The work done by the men of the 26th Engineers in these operations is a clear demonstration of the worth of technical army water-supply troops. Each man was working at his own trade, and the pressure and confusion of battle could not drive from him the ability to do the things which in civil life he had performed automatically, nor the ability to think intuitively in his own line of work. Added to this was the impelling desire in the face of suffering and death to perform some vital part in the game even if not in the forefront of the firing line.

The Armistice and the advance into Germany opened a new phase of the regiment's history. Company A and Company C were ordered to join the Army of Occupation. They preceded the infantry, examining each village, marking sources of water supply and sending back information to assist the divisional staff in the overnight billeting of marching troops. Upon reaching the Rhine, similar work was done in the bridge-head area. The other Companies, A, B, D, and E, remained behind in the deserted areas which so short a time before were the scenes of unprecedented

human activity. The construction of standard gage railway locomotive filling stations and salvaging of water-supply material were the prosaic duties performed during this period.

The real task of water-supply troops was completed soon after the signing of the Armistice, however, and by the middle of December, 1918, welcome orders were received by the various companies to proceed to the American railheads at Verdun and Sorcy-sur-Meuse, preparatory to assembling the Regiment for transportation back to the United States. There were many delays and trials, however, before the home port was reached. Not the least of these trials was a severe epidemic of influenza which ran through the regiment while in billets at the French village of Bourg-sur-Gironde, near Bordeaux. To the great sorrow of every member of the Regiment, ten of their comrades were victims of this epidemic. The memory of these men will live, however, not only among their comrades in service but among the grateful French villagers of Carbon Blanc, who regularly visit their graves with floral tokens of appreciation.

It was not until March 2 that the first detachment of the 26th Engineers embarked, and almost the end of March before the last detachment reached the United States. For the details of this time of waiting and of the "mill," and of the voyage home, the reader is referred to other pages of this history, where, under the title "The Journey Home," he will find much to awaken old memories and to entertain.

The story of each Company, with its difficulties and achievements, its experiences and travels, is told on the following pages.

Company A, 26th Engineers, Bourg-sur-Gironde, France, January, 1919.

COMPANY AND DETACHMENT HISTORIES.

COMPANY A.

The organization of Company A, 26th Engineers, at Camp Dix, N. J., dates from September 6, 1917. The officers assigned to that duty were Capt. Gerald W. Knight (commanding), 1st Lieuts. P. O'B. Montgomery, Arthur D. Weston, and Robert J. O'Meara, and 2d Lieuts. Frank C. C. Johnson and Ralph M. Nessler. Attached to the Company for duty were also Capt. Henry E. Chambers, Jr., and 1st Lieut. Newcombe. All were officers of the Engineer Reserve Corps and graduates of the first training camps.

From the start, organization became a race, it being known that the first company to become properly conditioned and trained would be the one selected for overseas service to fill the cabled request from the American Expeditionary Forces for water-supply troops. Recruits as they arrived were eagerly welcomed and sized up by the earlier arrivals. The quality of these recruits was most encouraging, practically all of them being either volunteers eager for action or members of the Engineer Enlisted Reserve Corps. The latter were generally men of considerable technical experience, who had "joined up" after careful consideration as to the best means of rendering service in the event of need. It was not surprising, therefore, with the enthusiasm and willingness displayed by all, that the necessary military fundamentals were quickly acquired, and Company A was designated to be one of the first companies of the regiment ordered to France.

During the period of training, Capt. Knight, having received orders to proceed immediately to France, had been relieved, and on October 12, 1917, Capt. Chambers was assigned the command of the Company. Lieut. Newcombe, after having given exceptionally valuable service in the days of final preparation, was detached from the Company just prior to its leaving Camp Dix.

The first move was a memorable one. Although the strictest secrecy had been enjoined, a well-organized intelligence depart-

ment, in spite of our extreme precautions, had apparently received complete information of the momentous developments which boded such ill to the Kaiser's ambitions. From early morning of the day of departure (Sunday, October 28, 1917), that particular section of Camp Dix occupied by the 26th Engineers was invaded by an army of fond and admiring sweethearts, wives, parents, and relatives of the heroes concerned. Once away from Camp Dix, however, the overseas detachment became a part of the mysterious unknown. There first ensued a night of silent travel by train to Hoboken, N. J. From this point the men were ferried to the docks where, under cover of the morning mist which still hung heavy over the river, they went aboard the U. S. transport *Agamemnon* (the former German liner *Kaiser Wilhelm II*). Every one was kept below deck and out of sight for two days and a night, until the transport finally slipped out of the harbor on the evening of October 31, 1917. It was then that the members of Company A actually realized that they were to be a part of the American Expeditionary Forces and among the first hundred thousand troops of that historic organization.

During the trip across, one incident stands out clearly and will long be remembered. The submarine danger was particularly acute at this time, as the Germans were bending every effort to stop the flow of American troops to France before it had acquired momentum. When the *Von Steuben*, another troopship of the same convoy, bumped into the *Agamemnon* from out of the blackness in the middle of the danger zone, with two dull thuds, there wasn't a doubt that a torpedo — or probably two of them — had found the mark. Notwithstanding the apparent certainty of fatalities, every man of Company A was at his proper station immediately after the accident, and stood as calm and collected as a veteran. Squad reports were given and received as coolly as if at practice; the "strong arm" squad was at the stairway to prevent a possible rush from below, and all guides and guards were promptly on their jobs. Whole regiments have been decorated for equal calmness under less trying circumstances. Fortunately the collision did not prove vital. All the sensations of an actual torpedoing had been experienced, however, and the incident served to bring officers and men together and add much to their mutual confidence.

The harbor of Brest was entered on November 12, 1917, and after a delay of two days the Company disembarked and entrained immediately for St. Nazaire. The Company was held here, awaiting definite orders, from November 17, 1917, to December 6, 1917, and during this interval assisted in the preparations being made at that port for the reception of the troops to come. Work involving more or less grading was done on roads, dams, etc., and time was found for an occasional hour of drill.

From St. Nazaire, Lieut. Weston and eight especially qualified men were called on detached service to Chaumont, for duty in the Office of the Chief Engineer, American Expeditionary Forces. Lieut. Nessler was left at St. Nazaire for duty with the engineer depot at that port. Sergt. C. H. Mayer was sent to Bordeaux with a small detachment, for duty with the engineer depot there. These detachments at the base ports rendered very valuable service to the Company and to the Water Supply Service as a whole, for, by their supervision of incoming freight, they insured the prompt forwarding of water-supply equipment and materials to the more advanced depots and so to the organizations in the field. Lieuts. Weston and Nessler were later transferred to depot organizations, but the enlisted men were eventually returned to the Company prior to its return to the United States.

Orders were finally received to proceed to Bourmont (Haute-Marne), and the Company again entrained December 6, 1917, on the now familiar "Hommes — 40, Chevaux — 8" De Luxe. Two days and a night were required for the trip, the destination being reached December 8, 1917. During this time a vast amount of French scenery had been absorbed, and except for the vigilance of the O.D.'s and train guards, a vast quantity of the national beverage would have suffered a similar fate. The inhabitants along the route were extremely enthusiastic over the arrival of American troops, and at every stop — and stops happened almost every half kilometer — would gather along the train with tokens of their appreciation in the form of dark-lined bottles, flowers, etc. Needless to say, the flowers were particularly acceptable.

Coincident with Company A's arrival at Bourmont came the first blizzard of the winter, and sunny France ceased to exist as such.

ENTRANCE TO SEICHEPREY DEEP WELL PUMP STATION IN DUGOUT UNDER THE BUILDING AT THE RIGHT.

Installed by the French under shell fire; abandoned practically to No Man's Land for several months in 1918; reinstalled and provided with an overhead storage tank and cart-filling hydrant by First Army Water Supply Service, immediately after the St. Mihiel offensive.

ENTRANCE TO XIVRAY DEEP WELL PUMP STATION IN DUGOUT.

This station was practically in the front lines of the Toul Sector until July, 1918; then in No Man's Land until reduction of St. Mihiel salient, September, 1918.

At Bourmont it was learned that the work ahead for several months would consist principally of preparing the various divisional areas for quartering American troops, in so far as the water supply was concerned. This work was of utmost importance, as, according to the plans, these areas were to serve first as training areas for newly arrived troops, and later as rest areas for divisions as they would be brought out of the line. It was therefore essential that these areas be properly supplied with water before the main body of the American Army arrived, and it was for this particular service that the two water-supply companies (A and B) had been rushed to France. The principal problems in this work were the installation of water and sewerage systems in camp hospitals, one or more of which were located in each area, and the supplementing or increasing the supply of water in the various villages at which troops were to be located.

Work was commenced immediately at Bourmont on a 300-bed camp hospital. Here a complete water system was put in, hospital plumbing installed, sewers laid, and sewerage tank constructed. Practically the entire Company, together with most of Company B, was engaged on this work, and it was completed well within scheduled time, although it was necessary to spend the first New Year's Day (1918) in France at hard labor.

The experience at Bourmont was very enlightening, and indicated clearly what was in store for Company A. Labor troops at that time did not exist in the American Expeditionary Forces, and the few doughboys who had already arrived had entirely too much to learn at their own trade to be called upon to furnish labor. It was therefore necessary that the water-supply company, although composed almost entirely of skilled and expert personnel, should not only make such installations as required special technical skill and experience but that it should also dig its own ditches, do its own backfilling, and in every way make itself independent of outside assistance. The spirit with which the majority of the men appreciated the situation and went at this heartbreaking work is greatly to the credit of themselves and the organization. "Squads right with a pick and shovel" became a byword. It is interesting to note here that ability with a pick generally demonstrated a man's ability at other work, and the men who

later made good as truck drivers, plumbers, mechanics, etc., were among those who dug the most ditch in the early days.

In addition to irksome labor conditions, the problems of supply — material, technical and personal equipment, fuel, etc. — were extremely difficult at times. The Company had left the United States with only the most limited personal equipment and no tools whatever. It was necessary to borrow, beg, buy, and, yes, at times even to steal from our French Allies the wherewithal to continue the work. On many occasions Edisonian ingenuity was displayed in devising makeshifts to accomplish the desired results in spite of the lack of " human " tools and material.

Needless to say, much wisdom was acquired at Bourmont. It was there that " Polly-voo " was first " compreed." Here also many became acquainted with the charms of " vin rouge " and " vin blink," a famous pair; and some perhaps attained a degree of familiarity with " coney-ack." It is further to be reported that some of the first French hearts of the war were broken during that winter in Bourmont. Here also top sergeants had ample opportunities to learn their duties; the supply sergeant and his staff found and produced equipment — provided of course it was really essential — from mysterious and unknown sources. The mess sergeant, at first haggard and careworn from trying to make one stick of wood do the work of a cord, finally became serene — he had staked out a claim to a wood mine of his own. About this time an ancient château was reported to have disappeared completely. However, certain medical neighbors, it is understood, generously contributed toward a more modern structure in its place — and the mess sergeant remained serene. And, speaking of learning, the cooks — but slum remained army slum even unto the Armistice. It is even suspected that the officers learned a few things at Bourmont.

In order to handle the large number of jobs assigned the Company, it was soon apparent that several detachments would have to be sent into the field to operate more or less independently. Although this arrangement brought up many difficulties, in view of the shortage of transportation, yet it utilized the abilities of the officers to the greatest possible extent and made possible the training of an unusually large number of efficient non-commissioned

officers. The technical supervision of the work in hand was altogether up to the officer or non-com. in charge of the job. Company headquarters handled all matters of administration, supply, discipline, pay, etc.

The first detachment, numbering some 70 men, under Lieut. Montgomery, left Bourmont on December 26, 1917, and proceeded by marching to La Fauche (Haute-Marne), some 15 miles distant, where a water, sewerage, and plumbing system for a 300-bed camp hospital was to be installed and repairs made to the village water supply. Lack of fittings and the mixture of American, French, and English material which had been supplied, as well as the lack of tools, made this a particularly difficult job, and numerous improvisations were necessary. On March 7, 1918, this detachment moved to Château-villain where the water and sewerage systems for another camp hospital were installed. Upon completion of this work, on April 22, 1918, the main portion of the detachment moved to Bar-sur-Aube, where a similar unit was installed.

On July 3, 1918, this detachment moved to Châtillon-sur-Seine (Côte d'Or), where it was joined by a detachment under Lieut. Hodnett from Treveray. Here four different detachments were formed, one each going to Laignes (Côte d'Or), Tonnerre (Yonne), Recey-sur-Ource (Côte d'Or), and one remaining at Châtillon-sur-Seine, to install water, sewerage, and plumbing systems in camp hospitals (300-bed) at each of these places. For these later jobs labor troops were available for excavation and back-filling, and the water-supply men were used solely on the more technical work.

On August 10, 1918, Lieut. Montgomery was detached from duty with the Company to report to the office of the Chief Engineer, Advance Section, Services of Supply, where he remained until the Company was reassembled in the latter part of September, 1918. Lieut. Hodnett then took over the work being done by these four detachments.

The second detachment to leave the Company was in charge of Lieut. Johnson, and was composed of 30 men. This detachment left Bourmont on January 10 for Chaumont (Haute-Marne), where they installed additions to the city water-supply system

and made an extension to the troop barracks. Plumbing was installed in the base hospital in that city. On June 21, 1918, the detachment moved to Rimaucourt (Haute-Marne), where they were engaged in installing water and sewerage systems for a 5 000-bed base hospital at that point until they rejoined the Company on September 19, 1918.

On January 14, 1918, the third detachment, consisting of Lieut. O'Meara and 32 men, a part of whom were from Company B, proceeded to Gievres to take charge of the water-supply section of the engineer depot at that place. Work here was monotonous and irksome, but of the utmost importance, as on it depended the speed with which water-supply material could be forwarded to the troops in the field. Lieut. O'Meara was assigned to duty with the Office of the Chief Engineer, First Army, on July 12, 1918, and returned to the Company only after the Armistice. The Gievres detachment continued its work until August 18, 1918, when it moved to Beaune under Sergt. Malpede, to engage on water-supply construction at the base hospital. The detachment rejoined the Company in the latter part of September.

In the meantime Capt. Chambers, with the Company Headquarters and the main portion of the Company, moved on January 7, 1918, to Diallecourt (Haute-Marne), where a pipe line was laid bringing water into the village for use of troops. On January 25, 1918, move was made to Montigny-le-Roi (Haute-Marne), where water and sewerage systems were installed at a typical 300-bed camp hospital. It was here that Lieuts. A. R. Garnock and R. M. Hodnett joined the Company. Lieut. Garnock left at once for Prauthoy (Haute-Marne) with 40 men to make the usual installations in a 300-bed camp hospital and an extension to the village water-supply system. After completing this work he proceeded to Chassigny (Haute-Marne), to equip a billeting area; returning on May 30, 1918, to Les Franchises to rejoin the Company. Lieut. Hodnett remained with Company Headquarters at Montigny-le-Roi.

It was at Montigny-le-Roi that the Company was increased to a total strength of 325 men by the addition of 75 water-supply specialists sent over from the United States as replacements. This detachment was most welcome and was quickly absorbed

by the old timers, becoming, along with the rest, adepts with the pick and shovel.

Upon the completion of the Montigny job, Company Headquarters moved to Rimaucourt on April 11, 1918. Work here was of general character, it being practically the only non-water-supply work that the Company had been engaged upon. During this period a very interesting trip was made to Bordeaux by Capt. Chambers and fifteen selected truck drivers, for the purpose of securing motor trucks and automobiles for the organization. The transportation which was obtained relieved a very pressing problem and enabled the Company to carry on work much more effectively.

From Rimaucourt the first detachment of Company A was sent up to the vicinity of the active front, — Corp. Owens (later Sergeant) and 8 much-envied comrades, after being equipped with gas masks and tin helmets, going to Ourches where a water supply was installed for an aviation camp. Here "Jerry" was heard and seen for the first time. In fact, from accounts, it is surprising that any member of the detachment lived to tell the tale. They all did, however, and told it well when they later rejoined the Company at Les Franchises. Shortly after, on May 11, 1918, Lieut. Hodnett and 32 men, also equipped for battle, proceeded to Colombey-les-Belles, where wells were dug, pumps installed, and pipe line laid for another aviation camp. Considering the number of hostile air craft brought down by this detachment, the amount of water-supply work installed was remarkable. Upon completion of the project, the detachment proceeded up a little farther to Treveray for a short job, after which they joined Lieut. Montgomery's detachment at Châtillon-sur-Seine.

On May 18, 1918, Capt. Chambers moved with Company Headquarters to Vittel, where improvements and extensions were made on the water-supply and plumbing systems of the two large hospital centers at Vittel and Contrexéville. Upon the completion of this work, Headquarters were moved, June 12, 1918, to the hospital camp at Les Franchises, on the outskirts of Langres, where it was joined by Lieut. Garnock and his detachment and by Corps. Owens and Dyson with their men. Here work was

begun on the installation of water, sewerage, and plumbing systems for a 5 000-bed base hospital and upon an auxiliary water supply for the city of Langres, the population of which city had suddenly been doubled by the large army schools established there. It was on this job that the water-supply men really came into their own, because the work was of sufficient size and variety to require the service of all the specialists. Concrete men, cast-iron pipe men, sewer men, plumbers, blacksmiths, pump men, riggers, carpenters, all were worked at their particular trades — all except, of course, the Gold Bricks, who became a strictly limited and closed corporation. Ample labor was available for the first time, several hundred colored troops being used for the excavating, back filling, concrete mixing, etc. Briefly, the project included the laying of some 16 000 ft. of 6-in. cast-iron pipe, the construction of a reinforced concrete rapid sand filter of approximately 1 000 000-gal. capacity, with a 50 000-gal. clear water reservoir and sludge beds, the installation of one high-pressure steam pumping plant and one low-pressure gasoline engine driven pumping plant, the erection of two 23 000-gal. elevated wood tanks, the manufacture and laying of some 22 500 ft. of 6-in. and 8-in. concrete sewer pipe, the construction of masonry sewerage tank and numerous grease traps, manholes, etc., and a complete system of modern hospital plumbing.

During the course of this construction various other work was carried on in the Langres vicinity. The ancient and venerable city pumping plant was overhauled and operated by Sergt. Stolte and a crew of dare-devil engineers and pump men — the dangers incurred being at least equal to that undergone by shock troops at the front. The boilers held together, however, in spite of lack of water columns and pressure gages. Water supplies were installed in a number of old forts surrounding Langres, which were now used for school purposes.

During the months of August and September, while the German drives were in progress and the Allied counter attacks were starting, it was very trying to remain on routine construction work, even of high importance, while other organizations were being rushed into action immediately upon arrival in France. Every available minute not required on the work was put in at drill, —

bayonet exercises, gas practice, open order work, etc., — in order that Company A would be prepared in case of call. The long-hoped-for orders arrived at last, and the entire Company was mobilized at Les Franchises, equipment completed, and on September 20, 1918, the outfit entrained for Commercy to become a part of the American First Army. A few days' delay was experienced at Commercy, which time was put in to good advantage at more drill and target practice, after which a march was made to St. Mihiel, where headquarters were established on October 4, 1918.

Shortly after arrival at St. Mihiel, 1st Lieut. A. C. Eckert and 2d Lieut. R. E. Field were assigned to the Company for duty. Lieut. Garnock had been previously relieved from duty to become Water Transport Officer for the First Army, and Lieut. Hodnett's services were of such value to the construction work in the Advance Section, S.O.S., that it had been found necessary to leave him behind when the Company moved forward.

To the men who had toiled so monotonously for so many months in the quiet areas, St. Mihiel, with its evidences on every side, was almost too good to be true. Camouflaged roads, ruined villages, barbed wire, and trenches — the scene was most surely getting warm. The elusive Boche was at last within striking distance. No wonder that he was observed with mingled feelings of curiosity and hate when a squadron of his planes visited the village the first night after Company A's arrival and dropped several tokens of his esteem for the newcomers.

The work began at once of supplying water to the troops stationed in the sector bounded on the northwest by a line through Fresnes-en-Woevre, Les Eparges, Mouilly, Ranzieres, and Recourt, and on the southeast by a line through Woel, Vigneulles, Mont Sec, Raulecourt, Jouy, Aulnois, and Vertuzey, and on the northeast by the front-line trenches. The situation was somewhat peculiar at this time, in that, while the Company was operating under the American First Army, it was supplying a sector which was occupied by French troops, the headquarters of the II French Colonial Corps being at St. Mihiel at this time. The Company was quickly distributed over the area, replacing French water-supply troops and a detachment of the 37th Engineers which had been used for water-supply work.

This distribution consisted of putting out pump operating details of from one to three men, water-point patrols and guards and construction parties for new work. Company Headquarters with storehouse, shops, garage, etc., remained at St. Mihiel, although the working parties in many cases pressed close to the front lines. The work of the construction parties consisted in the installing of horse troughs, canteen fillers, water-cart fillers, pumping stations, reservoirs, tanks, and pipe lines for water points, the erection of shower baths, and the repair and upkeep of partly destroyed French and German water systems in several villages.

On October 21, 1918, Capt. Chambers was relieved from duty with the Company he had commanded for over twelve months, to assume the more important duties of Supply Officer for the First Army Water Supply Service. Lieut. Montgomery succeeded to the command of the organization.

When the American Second Army took over the operations in the St. Mihiel sector, Company A was attached to that organization. The signing of the Armistice found it handling its assigned territory efficiently and always on the lookout for a forward move.

On December 20, 1918, the Company was reassembled and moved to Sorcy (Meuse) for entrainment to Bordeaux and embarkation to the United States.

Members of the organization when recounting their experiences and deeds during the World War to their numerous grandchildren, will experience many feelings of satisfaction and pride in the part which they played during those eventful months. Though the vastly larger portion of the work lacked the glamour and glory of the storybooks and war correspondents' accounts, it was nevertheless of utmost importance, and, in view of the amount of work produced, it can be said without exaggeration that the services of Company A played a very appreciable part in the success of the American offensives. And ever to be remembered are the wonderful hospitalities accorded by the French people to the first American troops to reach France, an experience which organizations arriving at later dates may well envy.

Water Point at Grosrouvres — Toul Sector.

Facilities for animal watering (at left), portable shower bath (center), and light railway locomotive filling (at right) 15 000-gal. wood-stave tank, supplied from spring by gravity.

Company B, 26th Engineers, Bourg-sur-Gironde, France, January, 1919.

COMPANY B.

Company B began its existence as a military organization at Camp Dix, N. J., September 4, 1917, when the first officers of the Company reported for duty. Volunteers who had enlisted for the water-supply regiment soon began to arrive at the camp and were assigned in equal numbers to Companies A, B, and C.

Elementary drill began at once for the members of Company B, under the direction of its commanding officer, Capt. Arthur H. Pratt. The first groups to be taken on the drill field presented a disheartening spectacle, in spite of their enthusiastic efforts to follow the drill master. It seemed as though half a dozen military outfits had been distributed among 20 men, for one could boast of a campaign hat, another had but a pair of canvas leggings worn over his civilian trousers, while several men had no military clothing whatever to distinguish them. However, as the groups on the drill field grew larger, sufficient equipment for all was procured, and under the direction of Capt. Pratt and Lieuts. Hall, Baxter, Church, Forde, and Beck the Company began to present a more soldierly appearance.

The novelty of being a soldier had hardly commenced to wear off when rumors were circulated to the effect that the Company was soon to embark for France. Unlike most army rumors, these particular rumors proved to be accurate, for orders were received the latter part of October for Companies A and B to prepare for embarkation. Since Company B had not reached full strength, men from the remaining companies were transferred to it. A detachment of well drillers, selected from the camp at large, completed the quota.

Finally, on Sunday night, October 28, the two companies were formed, and, with a most impressive atmosphere of secrecy, marched to the Camp Dix station and proceeded by rail to Jersey City. From there they were transported by ferry to a gang-plank of the U. S. transport *Agamemnon*, formerly the German *Kaiser Wilhelm II*. After many hours of waiting in New York

Harbor, the *Agamemnon*, on October 31, steamed oceanward. Even though it was evening, the majority of the men were able to obtain their first view of the New York City sky line and the Statue of Liberty.

After the lights of America had faded into the darkness, the troops on the huge transport resigned themselves to the coming voyage. As soon as possible they were assigned to lookout posts all over the decks, for the purpose of watching for submarines. Happily, not a glimpse of the dreaded peril of the seas rewarded the vigilance of the lookouts.

Although no submarines were encountered, there was an occurrence which afforded all the thrills of an actual torpedoing. On a dark night, when the convoy was within the danger zone, two terrific concussions were felt. Men were shaken from their bunks. To every one came the one thought, — "Torpedoed!" Not until several minutes later did it become known that it was a collision which had occurred. During all that time there was no confusion, the men either went to, or remained at, their bunks, as they had been instructed to do at "abandon ship" drill. Their conduct was most gratifying, as it indicated good discipline of the men, some of whom had been in the army only two or three weeks. It was the transport *Von Steuben* which had collided with the *Agamemnon*. After a flash of lights, a blast of the siren, and a few minutes of lively signaling to the other vessels of the convoy, the *Agamemnon* proceeded to get away from the scene of the accident as quickly as possible. Upon examination, the damage resulting from the mishap was found to be small. After three days more of unusually pleasant weather the convoy entered Brest Harbor. For five days the men were held on board ship, awaiting decisions and trains. Finally, on November 17, the Company disembarked and was transported in one of those horrors of war, a French troop train, to Camp No. 1 at St. Nazaire.

Owing to the scarcity of labor at the latter port, the members of the 26th Engineers were immediately assigned to various kinds of work, most of which was under the direction of the 17th Engineers. There was pick-and-shovel work on a dam project at St. Nazaire. In addition, detachments were sent to several hospitals in the neighborhood of St. Nazaire to make plumbing repairs.

On December 6, 1917, 100 men, in charge of Capt. Pratt and Lieuts. Baxter, Church, Forde, and Crowell (attached), were ordered to Bourmont (Haute-Marne). The remainder of the Company, under Lieuts. Hall and Beck, continued at work in and around St. Nazaire, several additional detachments being sent out to new projects or to repair plumbing systems. Through the efforts of Lieut. Hall, positions which were more suitable to the ability of the men were procured for those not on detached service. Truck drivers were placed on trucks belonging to the 17th Engineers, and men with clerical experience were assigned to various organizations as they were needed.

In the meantime, the detachment at Bourmont was put to work on the water-supply, sewerage, and plumbing systems for a 300-bed camp hospital. The work was carried on under the most difficult conditions, and, owing to the lack of facilities and inclement weather, there was considerable delay. The men were obliged to live in old, crumbling stone structures in the village of Bourmont, the best billets the humble town afforded. Only their tenacious spirit prevented a number of the men from succumbing to the severe weather, mud, and snow of the winter months. While the main detachment was working on the camp hospital at Bourmont, three smaller detachments were sent out. The first of these, consisting of Lieut. Church and 20 men, went south to Is-sur-Tille for the purpose of establishing the water-supply branch of the Advance Engineer Depot at that place. Although the work of handling heavy pipe was rather hard for the men, several excellent records were made in loading and unloading train loads of pipe and other engineer supplies for the troops at the front. The other detachments went north to install camp water-supply systems, one at the First Corps School at Gondrecourt and the other at the First Air Depot at Colombey-les-Belles.

With the coming of spring the portion of the Company remaining at Bourmont moved to Huilécourt, a village several kilometers from the site of the Bourmont hospital. Here life assumed a somewhat brighter aspect, because the billets were much better than the cow stables of Bourmont. Moreover, the French people accorded them a warm welcome. These were the first Americans to be quartered in the village, and such a good relationship was

set up and maintained with the civilians, that after their departure the mayor wrote a formal letter of appreciation and extended an invitation for the Company to return for a visit.

Lieut. Church and most of the men at the Engineer Depot at Is-sur-Tille were, on February 5, 1918, sent to the historic and picturesque city of Langres (Haute-Marne). There they operated and made extensive repairs to the water system of the city. This work proved to be a pleasant change compared with that at Is-sur-Tille, largely because most of the men could be assigned jobs more suitable to their ability.

Upon completion of the Bourmont hospital work, the Company left Huilécourt on March 14 for Humes, a village located just outside the city of Langres. There the Company installed water-supply, sewerage and plumbing systems for another 300-bed hospital. As a side issue, about 2 000 ft. of road were built around the camp hospital. The latter work involved the quarrying and placing of many tons of rock. The " lay " of the land was much more favorable than at Bourmont, and with the experience gained there the work was under way in a short time. Fortunately, the structures of the hospital were found sufficiently completed to house all of the men, another change for the better in living conditions.

Toward the end of March the Specialist Detachment, which had long been awaited from the States, arrived in Humes; 76 of the members were assigned to Company B. They were accorded a warm welcome, and, since the new men were from all parts of the " Old Country," several friendships were renewed. Among the cities most noticeably represented was Dallas, Tex., which metropolis could not boast of a more ardent and persistent booster than one of the members of the new detachment.

With the assistance of the Specialist Detachment, the work at Humes was quickly completed and the Company moved to Les Franchises, just outside of Langres. There work was begun on the laying of a 2-mile pipe line from the River Marne, at a point just below the site of a 5 000-bed base hospital, to the city of Langres. Also, for the hospital, some plumbing installations were made and plans were drawn for a very extensive water and sewerage system. The versatility of the members of the Company

was instanced when it became apparent that no sewer pipe could be obtained, for within two weeks molds were built and about 3 000 ft. of 6- and 8-in. concrete pipe were manufactured.

While the Company was at Les Franchises a detachment of men, under Lieut. Forde, went to Rimaucourt, about 40 kilometers northwest of Langres, for the purpose of constructing a water system for another base hospital. Work on this project had been started by Company C of the 26th Engineers.

Up to this time all of the work performed by the Company had been under the direction of the Office of Section Engineer, Advance Section, Services of Supply. Primarily it had been concerned with the preparation of rest and training areas for American troops.

A distinct change took place, however, late in May, when part of the Company, consisting of Capt. Pratt, Lieut. Baxter, Lieut. Forde, and 50 men, moved north into the Zone of the Armies and reported to the Chief Engineer of the I U.S. Corps. Other detachments were brought up as they could be relieved from their work in the Services of Supply. The first station of the Company was at Lagney (Meurthe-et-Moselle), a town about 12 kilometers from the front lines in the sector north of Toul. At that time the sector was held by the 26th U.S. Division, operating tactically under the XXXII French Corps and the Eighth French Army. Within a few weeks the remainder of the Company was brought to Lagney, and the work was begun of taking over from the " Service des Eaux " (Water Service) of the French Army the water supply of the entire Toul sector. Primarily this consisted in replacing the French motor pump operators at each of the many water points, repairing water points found in bad condition, and establishing several new ones where most needed.

At the first opportunity, a formation of the entire Company was held for the purpose of acquainting the men with the new conditions under which they would now be obliged to work. Toward the close of his talk, Capt. Pratt remarked that the Company was now where it had longed to be ever since landing in France, namely, " at the front." This fact became decidedly apparent to the members of Company B on the following Sunday. During the preliminaries of the weekly Company inspection, a

German battery decided that it would stir up the inhabitants of Royaumeix, a village about three kilometers from Lagney, and in plain view of each man in the formation. Huge shells were to be heard whistling through the air on their way toward the little town, and then a cloud of smoke and débris would be seen to rise among the structures. Several seconds later a reverberating boom would reach the ears of the newcomers. Thrills of exultation coursed up and down the spines of some; in the case of others, thrills of a less exhilarating nature were experienced at seeing this example of the Hun's precision with big guns. The guns causing the damage were, of course, far out of sight.

The work of replacing the French pump operators was taken up first, and practically every man in the Company capable of operating a gasoline engine was given a chance to demonstrate his ability. Several of the water points were near the front line. The lack of opportunity for adequate military training was illustrated by the manner in which operators for these latter stations were selected. Although the men had had rifles for over three months, none of them had had any target practice. As it was quite likely that those in the advanced positions might have urgent need of a knowledge of shooting, they were picked from men who had had hunting experience in the American West.

The members of the Company who were first actually to experience shell fire were a detail of 15 men sent to an advanced position to place a large concrete tank. Every man in the Company, including the kitchen police, volunteered for this work. A day was spent in rehearsing the unloading of the cumbersome tank from the 5-ton truck on which it was to be carried to the ravine immediately northeast of Beaumont. During the first rehearsal the foreman of the detail, whose duty it was to place rollers under the tank, had his hand severely mashed. For fear of losing this coveted opportunity, he made light of the injury and insisted on accompanying the expedition. The detail left the next morning for the site where the reservoir was to be installed. It reached its destination without mishap and during a nerve-racking rain of shells the tank was lowered into a hole previously dug by the infantry occupying that position. The men emerged from their baptism of shell fire without a scratch, and

returned to their billets before daylight to wake up the other men and relate the adventures they had experienced.

During the next few days details for various purposes were dispatched into the area of enemy shell fire. In the course of a week or two the members of the Company regarded themselves as veterans, and the excitement of working in the midst of constant danger gradually wore off. Seldom a night passed that numerous anti-aircraft batteries on all sides were not heard at their slumber-disturbing work of driving away the persistent German bombing planes. Toul appeared to be a Mecca for the bombers.

During the period preceding the St. Mihiel drive, there were incidents without number in which the men of the more active details were participants. Among those most conspicuous in the memories of the men of Company B was that of the pump operator at Xivray, who was obliged to abandon his dugout station and join the infantry in repulsing a heavy attack by a large enemy raiding party. Without previous knowledge of the use of hand grenades, he placed several of them in the midst of the attacking party with apparently effective results. This feat brought mention in the orders of the day of 26th U. S. Division. Another operator at the same station had an unusual experience. The infantry occupying the position around the water point withdrew from Xivray for tactical reasons, but neglected to inform the pump operator. He emerged from his dugout the next morning to find that he was the one American left in a town which had thus become a part of No Man's Land. Fortunately the Germans had not discovered the fact. He lost no time in returning to more desirable surroundings. As soon as the matter was reported to Company Headquarters, a party, including the operator, was chosen to go back after the pump and engine and so render the water point useless to the enemy should he attempt to occupy the ruined town. The expedition was made at night. Headed by Lieut. Church the party stealthily entered the town and safely brought out pump and engine.

But the field of work was broadening. On July 15 a detachment of 100 men and two officers left Lagney for the Baccarat (Meurthe-et-Moselle) front. There they installed water-supply facilities for the men and animals of the 37th U. S. Division holding the sector.

Water Purification Plant under Construction at Euvezin (Meurthe-et-Moselle), showing upper settling reservoir with gravity feed through sand filter to lower clear water reservoir (after St. Mihiel offensive).

Closer View of Raw Water Pump, Sand Filter Tank, and Clear Water Reservoir, from which water was pumped to storage tank at higher level. Water was chlorinated as pumped.

Earlier in the war, Baccarat had been taken by the Germans but retaken by the French. The inhabitants of the city naturally were the more eager to show their appreciation of their new allies, the Americans. Not only were the men provided with the best of billets, but they were shown all kindness at the hands of the civilians during the time they were stationed there. On August 18 the detachment was ordered to return to the Company, and it was with great reluctance that it took its departure from the pleasant little city.

Intensive work was begun about this time on the task of providing water for the large number of men and animals that each day, or rather each night, were moving into the Toul sector preparatory to the St. Mihiel offensive. Soon it became necessary for the Company to work night as well as day, not merely in order to take care of the additional work, but to escape detection by the vigilant enemy observers on Mont Sec and in the air. Water-purification trucks known as " sterilabs " were placed at prepared locations around the numerous small lakes of the sector, and five or six details were engaged at all hours in enlarging the available capacity of the many springs and previously constructed water points.

Carpenters rushed the construction of water troughs which were installed at many points. These troughs were used to water the thousands of horses that were concealed in every patch of woods throughout the sector.

The rapidly multiplying number of troops and animals necessitated the pressing into service of improvised water-tank trains. While the mechanics of the Company were engaged in equipping these motor trucks with water tanks, other details were busy installing a number of special pumping plants and constructing reservoirs as filling stations. These provisional truck trains were later replaced by a permanent and better equipped train. Their function was to transport water to advanced points and to other places where it was impracticable to develop local water supplies. In proportion as territory was occupied, new problems presented themselves which had to be solved in a minimum time. The work of the water-tank train increased in volume as the troops moved forward, and a number of details were kept busy erecting

temporary canvas reservoirs as advanced water points. The reservoirs were ordinarily placed in an excavation.

One of the many experiences deserving mention in connection with the water-tank train is that of the inexperienced water-tank truck driver, who, in an effort to reach his destination, became so desperate as to inquire his way of an M.P. As a natural consequence, he was misdirected and in the darkness drove past the American front line. Before he knew of the impending danger, his truck and he became the target of an enthusiastic Boche machine-gunner who proceeded to make a sprinkling wagon out of the water tank. Fortunately the driver was not hurt and had the presence of mind to turn around and make his 5-ton truck emulate a jack-rabbit.

During the various phases of the St. Mihiel offensive there were but few members of the Company who did not have opportunity to experience the enemy's fire, both from machine guns and artillery. The water sample collector of the Company had the distinction of having a German battery place fifteen " 77 " shells around him in an effort to blow him and his motorcycle from the map of France. The aim was bad, however, and both rider and motorcycle returned safely to headquarters.

Another experience was that of two officers who were making an inspection of the water supply in the ruined village of Vilcey, close to the front line. A soldier emerging from a dugout offered to show them where one of the original village fountains had been located. He warned them, however, to keep close to a wall, explaining that whenever Fritz on the opposite hill observed any one in the street, the enemy artillery opened up with three shells. The party had just reached the fountain when a " boom " was heard and the guide yelled " Here it comes ! " and dived below ground. The officers followed with more speed than dignity, getting down just as the shell exploded. Two more shells followed and then the guide, knowing how systematical the enemy was, assured them that it was all over for the time being, and so it was.

On October 17 the detachment which had been left at St. Nazaire rejoined the Company. The latter had by this time moved to Grosrouvres, a painfully small village somewhat closer to the front than Lagney. Although for the first few days the new-

comers from St. Nazaire had some difficulty in accustoming themselves to the strange surroundings, they lost no time in falling in with the work, which was radically different from that which they had had at the base port.

The difficulty which had been experienced by the regimental commander in getting these men back to the Company was extremely complimentary to them, indicating, as it did, that they had made themselves well-nigh indispensable to the work on which they had been engaged.

During the active period of the St. Mihiel operation, from August 23 to September 18, the territory located between Bouconville on the west, Pont-à-Mousson on the east, Toul on the south, and Thiaucourt on the north, was cared for by three water-supply companies, namely B, D, and F, of the 26th Engineers. Companies A and B of the 27th Engineers were attached and rendered effective assistance. A detachment of Company E, 26th Engineers, also assisted, but on September 17, with only a few hours' notice, all of the units except Company B, 26th Engineers, were withdrawn to the Argonne-Meuse front and their work was taken over by Company B.

The area was now termed the "Toul District." To take care properly of the work, large detachments were stationed at advantageous points. One of these detachments, stationed at St. Baussant, constructed at Essey a permanent water-purification plant consisting of large concrete sedimentation basins and a filtration plant of considerable capacity. Another detail of the same detachment worked on a somewhat larger and more elaborate plant of the same description at Euvezin. These plants were principally utilized as filling stations for the water-tank trains which were now operating successfully in all parts of the newly occupied territory. At Gezoncourt a detachment was kept busy in operating and maintaining the many water points in that neighborhood and constructing new ones as they were needed.

On the day of the first Argonne-Meuse attack, September 26, Private Daniel L. Tankersley, while on detached service with Company F as a motorcycle side-car driver, was mortally wounded while at a heavily-shelled road mine crater with Lieut.-Colonel (then Major) Scheidenhelm, regimental commander.

The termination of hostilities at 11.00 A.M., on November 11, brought no reduction in the work of the water-supply troops. In fact, for a time the amount of work increased because it was found necessary to extend the water facilities in order to supply the apparently never-ending stream of men and horses on the way to Germany. Several German military pipe lines were traced to their sources, and some German pumps were repaired and put to work. A detail, which was operating near the village of Jaulney, one day chanced upon a strange looking object on wheels. Upon examination it proved to be a German water purifier. Compared with the mobile purification trucks then in use by the 26th Engineers, the apparatus was crude, but no doubt it was effective. Upon returning to headquarters the detail reported its find to Lieut. Baxter, the company commander, with the result that it was brought into camp. Steps have since been taken to have it preserved as a souvenir and shipped to America, to be exhibited with captured artillery and other war trophies.

Six days after the beginning of the Armistice, a detachment under Lieut. Baxter joined the advance guard of the right column of the Army of Occupation in its march to Germany. Its work was to locate sources of water supply, and make the water available for the men of the main column by cleaning the sources and installing hand pumps where necessary. Signs were posted, giving the direction to water points and stating the quality of the water. After proceeding as far as Briey, this work was turned over to Company C.

The field of operation, however, was later extended farther toward the Rhine. On December 8 Lieut. Church took a detachment into Esch, in the Grand Duchy of Luxemburg, for the purpose of preparing that district for use as a divisional billeting area. A short time later a detachment under Lieut. Howard proceeded to Conflans to perform similar work in that district. Both detachments remained long enough in this territory recently held by the Germans for the men to add a few words of guttural German to their vocabulary of soldier French, and also to find that there were "Fräuleins" who possessed charms as alluring as those of the "Mademoiselles." With a bountiful supply of souvenirs the two detachments rejoined the Company a few weeks later and related their adventures and the sights they had seen.

During the absence of these detachments, the remainder of the Company was largely engaged in salvaging water-supply installations the usefulness of which had ceased.

The variety and amount of work done by, or under the direction of, Company B while at the front, as well as that done previously in the S.O.S., are shown in the summarized statement of activities of the 26th Engineers as part of American Expeditionary Forces.

There were several organizations which furnished a great deal of assistance in this work. Operators for pumping stations were furnished by Company A, 37th Engineers, and Company B, 24th Engineers. Labor and some skilled help were furnished by Company B of the 27th Engineers, Company D, 59th Pioneer Infantry, and Company B, 542d Labor Battalion. The water-tank trains, all of motor trucks, were operated by the 1st Provisional Water Tank Train and by Company B, 302d Water Tank Train.

When the Company entered the Zone of the Armies, it operated as part of the French Eighth Army, but under the technical supervision of the Chief Engineer (Water Supply Officer) of the I U. S. Corps. Nevertheless it served, primarily, United States divisions. The relations of the Company with the French "Service des Eaux" were harmonious. About the middle of July, when the American First Army was organized, the Company came under the jurisdiction of the Chief Engineer (Water Supply Officer) of that army, and served under him during the St. Mihiel offensive. About October 9 it became a corresponding part of the newly organized American Second Army, and remained with this army until relieved from duty at the front. United States divisions occupied the areas looked after by Company B as follows: 26th, 82d, 89th, 90th, 42d, 37th, 7th, and 28th. Other army troops working in the area at the same time were: 23d Engineers (road), 21st Engineers (light railway), and the 12th Engineers (railroad).

When orders were received on December 20 for the Regiment to assemble, principally at Sorcy-sur-Meuse, for the purpose of proceeding to a port of embarkation, the members of the Company felt with satisfaction that they had done good work.

COMPANY C.

" All out! Come on, you stiffs! Make 'er snappy."

" Say, any one find a pair of shoes? " (Abbott, from under his bunk.)

Kid Hardship, standing on one foot trying to get his pants on, asks with chattering teeth how in several different things any one expects a guy to get dressed in five minutes.

" Gibby," looking down the line (he lost his notebook containing the roll), calls the names of those he sees, and reports: " Sir, all present." Then, " Right, face; forward, march; double time, march! " and off we stumbled, half asleep, over the frozen ground in the morning trot around the barracks. Oh, boy! those were the good old days at Camp Dix!

" Say, what the hell are you fellows doing in here? You're supposed to be out with the rest of them, double-timing. K.P. for yours." Darn the " Top "!

And then breakfast: Coffee, hash, prunes, and bread. Recently, Dave Thompson said that the reason that the coffee tasted like mud was that it was fresh ground.

Well, you know how it was, — " Pete " Grant and " Fergy " always at the head of the line, yelling " Hold that line," and " When do we EAT? " till Tom blew the whistle; then a grand rush to Eddy Kelsey and his G. I. can full of hash.

Breakfast over, came the job of making the bunks and policing up. Blankets folded so, shoes put here, shelves arranged one way and barracks bags another. A wash and a shave and whir-r-r-r-r, " All out. Rifles, belts, and mackinaws," and our daily round had begun.

Before we go further, let us say a word about the beginning of Company C. On September 10, 1917, according to Regimental Special Order No. 1, Capt. G. W. Stickney, 1st Lieuts. C. H. Lee, J. C. Pritchard, and R. Newfeld, with 2d Lieuts. S. J. Benedict and V. J. Loughran, were assigned to the Company.

On the 11th, Special Order No. 2 attached 1st Lieut. Rees W.

Willard for duty. Two days later Charles Gokmant and Walter Halliday headed the Company roll, and on the 17th the names of Bill Barndt, Jimmie Kelliher, and Tommy Tate were added. On October 16 Lieut. Lee was detached for service in France, and Lieut. Willard was assigned for duty. During the following weeks the Company rapidly increased in size, and by the morning of December 8 had reached its full strength. Lieut. Pritchard was detached from the Company, January 6, much to our disgust. Later in the month Lieut. Neufelt was relieved from duty, and on the 26th was replaced by Lieut. Ernest A. Shafer. Lieut. Wells was assigned to the Company on February 23, and, during the latter part of March, 2d Lieut. Loughran was commissioned as 1st Lieutenant in the Sanitary Corps and attached to the Company. The last officer to be assigned was 2d Lieut. W. C. Laughlin, on March 28.

Along in December we began to take those hikes we enjoyed so much, to Jobstown, Browns Mills, Pointsville, and other fence corners. When we stopped for a rest it was always in the woods, or some place equally interesting. The man acting as right guide certainly lost all his popularity on those hikes. To make up for them, however, was the daily trip to the Soldiers' Club in Wrightstown.

Thanksgiving dinner was a thing to be talked of for months. The three dinners, Thanksgiving, Christmas, and New Year's, were the only meals that Tommy, our official kicker, did not Howell about. Even on our hike to Coblenz, Tommy made disparaging remarks about corned Willy, and with tears in his eyes would beg some one to tell him that he too remembered those dinners. You'll have to hand it to Tom Griffin, he was some cook; and when Dave Thompson was mess sergeant, WE ATE.

Let us go back a little bit: An hour's drill, three minutes' intermission, just long enough to get into the barracks and light a cigarette; more drill, another intermission, a final formation, and then just time to wash up before dinner. (Oh, yes! We washed in Camp Dix. We lost the habit in France, but you may be able to recall days in Dix when you washed three times.) An hour for dinner, and then that dam' whistle would blow and "Bucky" would have some more fun with us.

Speaking of drill, we must not forget the non-com. school that Lieut. Willard had. Those in it were interested all right, but it made them peeved at times to think that every one else was having a rest while they were working.

After we had all returned from the Christmas and New Year's furloughs, we had the " nut test." It was quite a success. Even though there were seventeen " A's " in the Company, it confirmed our opinion one of another.

Our real fire alarms — that is, the fire alarms given for a real fire — were exciting. But the night that " Gibby " had us half-way to the cold storage plant before he found out that the fire was in the latrine back of our barracks, was cold enough to take all the joy out of the excitement.

On January 14 we were put into quarantine for measles, and there we stayed till about February 22. That was a time to take the pep out of any one. We managed to survive it, and many things of interest happened during that time. One night O'Neil lost his bunk. We suggested that he ask Near, Anderson, or Wilcox where they got the sky hooks. Another nice zero night, McAdam took a bath. Just as he was drying off, some rough person threw a bucket of snow and water on him. Had you been across the street from the barracks, you would probably have thought that some one was crazy, racing around the building and dodging from side to side. You would not have seen " Mac " behind him (white does not show up against snow, you know). " Mac " has had chilblains ever since. Tommy Howell got in the same sort of a mixup, but his was slush and mud. It was a good thing that the jokes were pulled off in fun.

Do you remember " Pat " Patterson and his trial before the Kangaroo Court? It seems that he had been on a week-end pass and that when he came back he had brought (it was said) some souvenirs, and hidden them under his bed. Of course these souvenirs were produced as evidence, and " Pat " was deeply grieved.

And all this time the Amalgamated Association of Hard Boiled K.P.'s changed membership twice a week.

On February 7 we went out to see the British tank.

The week of February 10 we had lectures on " Gas and Gas Masks."

On the 20th we went to the rifle range, and from then till the 26th all we heard was: "Mark 18!"; "Say, who the hell is shooting on No. 4?" "Mark 18! Damn it!" The good scores we made came from our long practice at shooting snipe.

Tuesday morning, March 26, we were ordered to begin packing up. Good Friday night the whistle blew at 8.20, and at 8.30 we started for the station. The next morning, after an inspection at Jersey City, we boarded a small river steamer and went over to Dock No. 50 in New York. At eleven o'clock we were aboard the *Rochambeau* in the steerage. At 4 P.M. we sailed.

Capt. Stickney, being the senior army officer on board, assumed command of all American soldiers. The voyage was uneventful; no "subs" were sighted and there was not even a case of seasickness.

Do you remember that Frog who woke us up every morning at six, yelling, "*Café, café!*"? Those were great meals we had.

On Tuesday, April 9, we landed at Bordeaux and hiked about five kilometers to a "rest camp." Between showers we rested. Friday we hiked down to Carbon-Blanc and had our first taste of "III Classe" transportation. While on the train, we saw and heard our first barrage — the amount of glassware distributed on the right-of-way was a caution. In fact, one did not dare poke his head out of the window for fear of getting "beaned." We passed through Angoulême, Tours, Dijon, Is-sur-Tille, and finally detrained at Langres on Monday, April 15, after three days on the train.

Humes, about three kilometers from Langres, was our stopping place, and one to be remembered. Several details were sent out and some of us had a chance to see the medieval stronghold at Langres. Sunday, the 21st, the Company moved to Rimaucourt and had a real taste of mud. While there, we put in about five miles of water mains (don't forget all the ditches) and distributing lines for a 6 000-bed hospital. The Company also graded the sites and erected a number of demountable wooden barracks, and at the same time installed electrical connections and interior wiring. Here it was that our "Top" and the mess sergeant ran up against General Vin Blink. As usual, the superior officer won out.

From Rimaucourt five men were sent to Blois, another detach-

ment was sent to Langres, and still another to Bazoilles-sur-Meuse. On May 17 we began to sing that good old song, "O father, take down your service flag; your son's in the S.O.S.," for on this date the Company received orders to make up detachments to go to Mars (Nievre), Allérey (Saône-et-Loire), Mesves-sur-Loire and Joué-le-Tours, to take charge of hospital construction. Lieut. Shafer and 45 men went to Mars. Lieut. Wells and Lieut. Loughlin, with 90 men, went to Allérey. Lieut. Loughran and 45 men went to Mesves, and Lieut. Benedict and 49 men went to Joué-le-Tours. Lieut. Willard was retained for a time at Rimaucourt, to complete the water-supply system, with a detachment from Company B of the Regiment, and later was placed in charge of the water-supply installation for the hospital at Beaune. Capt. Stickney was stationed at Tours, maintaining general Company Headquarters, and making special investigations of water supply and sewage disposal in the base and intermediate sections of the Services of Supply.

All the detachments entrained together at Rimaucourt and proceeded to their various destinations. The work to be done was nearly everything in the engineering line, — the construction of barracks, water lines, pumping plants, sewers, roads, reservoirs, and railroad; the installation of electrical equipment and wiring, quarrying, and the operation of everything in the line of machinery from road rollers to stationary steam pumping plants. For the first time we were happy. Nearly every man was at his own work or something approximating it, and there was not the restraint incident to military formation. The actual labor in the hospital construction was done by Spanish, Portuguese, and French, although after a couple of months several American negro labor battalions were assigned to each hospital group. The men of Company C were used as foremen, except on those classes of work where skilled mechanical labor was required.

The hospitals at Mars and at Mesves were two of the largest in the world; each had a capacity of 20 000 beds in permanent buildings and wooden barracks, a crisis expansion of 20 000 beds in tents, and convalescent camp capable of holding four or five thousand more. At Allérey and Beaune all the water was secured from wells dug and bored by Company C men, and the entire

water supply and sewage system, as well as the electric generating plant and all wiring, was installed by our detachments. The hospital at Joué-le-Tours was built to accommodate 2 000 patients in permanent buildings, with tent space for 2 000 additional and 500 convalescents. The detachment at that station installed the water-supply system and all interior plumbing. The water was secured from two 600-ft. wells drilled by our men. From time to time, detachments were sent out to points in various base sections to drive wells for other hospitals and camps. The worth of Company C men in the hospital construction is shown by the following extract from a letter to the section engineer from Lieut.-Col. Huston at Mesves. The letter was written after the detachment had received orders to report to St. Aignan, preparatory to going to the front.

" The departure of the 26th Engineers who have been on this work since the early part of May and formed a big portion of what organization there has been here, will leave a big hole in our forces. Among these men are represented the following trades and their places should be filled at once . . ."

" Unless all these important places are filled with competent men at once, we almost might as well shut down."

" Right off the reel we will be crippled in deliveries of material and the water supply of the hospital will be in jeopardy, and without master mechanics our machinery will be laid up for want of drivers."

The following letter is self-explanatory:

AMERICAN EXPEDITIONARY FORCES

BASE HOSPITAL No. 26, A.P.O. 717, 2 Aug. 18

Lt.-Col. W. H. Artley, Q.M.C., N.A., A.P.O. 717

Dear Sir:

Again yesterday and last night, in an emergency which taxed the powers of Base Hospital No. 26 to the utmost, your splendid corps gave us the touch of the shoulder. Your men voluntarily worked alongside our men, rendering invaluable services throughout the day and night.

Permit me to again thank them and you for your generous assistance.

Respectfully,

A. A. LAW, *Major, M.R.C., Comdg.*

1st Ind.

Engr. Off. in Charge construction — Allery — 3 Aug. 18 — To C.O. Det. Co. C 26th Engrs. — Allerey

1. The above thanks are due you and your detachment.

W. H. ARTLEY, *Lt.-Col., Q.M.C., N.A.*

Company C did not confine its good work to physical labor alone, it "adopted" ten French orphans, which was announced by the *Stars and Stripes* as the A.E.F. record for a single company.

Lieut. Shafer is the only officer in Company C who was not nicknamed by the men. We had the "Boy Scout," "Charlie Chaplin," "Jess," "Benny," and the "K.O.," but "Tilly" was "Tilly" to the officers only. Here are a few questions to ask

COMPLETED WATER PURIFICATION PLANT AT EUVEZIN (MEURTHE-ET-MOSELLE).

Pumping equipment protected by means of sandbags and rock against aërial bombing.

our officers should you ever meet with them again: Ask "Tilly" about the M.P. and the nurse at Mars. Ask "Rocko," sometimes known as "Charlie Chaplin," how he got his arm broken at Mesves. Ask "Jess" to tell you the story of the high hat, the pair of pajamas, and the barracks roof at Beaune. There is a story told of a short, stout man, slightly bald, who insisted upon sitting on the railroad track at the road crossing at Rimaucourt, to count the stars.

September 16, 1918, the various detachments received an order to proceed to St. Aignan (Loire et Cher) for training in gas defense and to receive all necessary equipment preparatory to going to the front.. From St. Aignan, however, 1 officer and 9 men went back

to Mesves and 5 men to Mars, to help break in the men who were to relieve them. The rest of the Company entrained on September 28, and had its first taste of " Hommes — 36, Chevaux — 8." We spent one night on the train, a night at the barracks in Tours, a night in the French barracks at St. Dizier, and finally arrived at Clermont-en-Argonne, 5.30 A.M., October 2, to take up work, along with Companies D, E, and F, as army engineer troops (water supply), American First Army.

The first day at Clermont we saw several air fights and heard the continuous noise of the Argonne offensive. The Company was billeted in an old French hospital. The latter was situated on one of the main roads to the front, and from daylight until dark a continuous stream of loaded trucks passed the door. In one day, our friend, the M.P. at the corner, said he counted over four thousand trucks between daylight and dark.

Immediately after arrival at Clermont, detachments were sent out to various points in the northern sector of the First Army Water Supply Service, to assist Companies E, F, and D in the installation of water points required to supply troops engaged in the Argonne-Meuse offensive. One detachment of 25 men, in charge of Lieut. Wells, crossed the Meuse River north of Verdun and at Brabant joined a party from Company D. The first night they pitched " pup " tents, but before morning were in the deepest dugout they could find. By the next night they were installed in a palatial German dugout, excavated from solid rock and containing 42 bunks. This was home during the remainder of their five weeks' stay at Brabant. During this time, several canvas reservoirs were installed, one very complete gravity water point was constructed at Brabant, and pipe was laid for a similar one at Consenvoye. Though under shell fire during the entire period, not a single man was wounded.

Another detachment, under Lieut. Willard, put in a 15 000-gal. wood stave tank, centrifugal pumping plant, and standard gage locomotive filling station at Varennes. In that detachment were Fraser and Metheney who slept in the same dugout. Before the Hun had been pushed back out of range he used to send over a few " H.E.'s " every night. Well, one night they were dropping in the vicinity of Fraser's and Metheney's *abri*. One landed near

enough to jar them up quite a bit. In a minute or so Matt began to swear in a relieved tone of voice. Naturally, Fraser inquired why the relief. "Well," said Matt, "those dam' rats scare me to death, and now that last G.I. can chased them away."

Reconnaissance work was done by Lieut. Shafer in the vicinity of Montfaucon, tracing out German water-supply systems.

On October 18 the Company moved by trucks to Ancemont, where it was joined a few days later by the detachments from Mars, Mesves, and Joué-le-Tours. The Company was now given full responsibility for a sector for the First Army along the front east of Souilly (Meuse) and extending seven kilometers north of Verdun. This area had been developed by the French Second Army Water Service during the Verdun offensive and required but little in the way of new installations to supply the American troops now occupying it.

Previously, Company D, 37th Engineers (acting temporarily as water-supply troops), and Company A, 26th Engineers, had been operating in this area.

Two new installations were made, however, one in the Luxemburg Forest, consisting of a triplex pump, more than a mile of pipe line, three metal tanks, and hydrants at various points in the woods. The other installation involved a pump, reservoir, and pipe-line system, distributing water to the First Army Headquarters barracks at Souilly. The principal work of the Company, however, was the operation of pumping plants turned over by the French, of which there were fifteen, and the patrolling of all of the gravity water points.

That was when we sat on the world. With a nice pump house (and those French pump houses are "jake"), a nearby ration "dump," and for variety, a couple of air battles every day, we wanted nothing more. The ration "dump" was a real necessity, for the rations we drew from Company Headquarters were a joke. Do you remember the time you drew 2 lb. of flour, 4 lb. of coffee, 5 cans of monkey meat or "willie," a few odd cans of tomatoes, a couple of loaves of bread and 7 rolls of paper, to last 6 men four days?

One day while we were at Ancemont, a cable came for a certain Sergeant 1st Class, saying that he was the proud possessor of

twins. The Sergeant was out on D.S. and could not be easily reached. It happened that one of our lieutenants met him, in a few days, and told him the news; but wanting to break it gently, he said it was triplets. Max believed him, too, and wrote home immediately saying how glad he was. When he got back to headquarters and got the official cable — well, that is another story.

Along about the 8th of November, we heard some rumors of an Armistice, but, as usual, no one put much stock in it. On the 11th most of us knew that firing was supposed to stop at eleven o'clock. Some few on duty very near the front knew nothing of the Armistice, so when firing ceased at the apoointed hour, one can easily imagine their thoughts. Two of the boys, stuck away out in the woods, thought it was a German trick, and when they heard all the celebrating around them and saw flares going up in broad daylight, they gathered up all the ammunition they could find and hiked for the nearest shell hole.

By the 17th of November all detachments were recalled, and we were relieved from duty with the First Army, and ordered to report for duty with the Third Army (Army of Occupation). The Company was split into two detachments, one being attached to the 1st Engineers, 1st Division, and the other to the 6th Engineers, 3d Division. On the afternoon of the 17th we started on our hike to Coblenz, with Lieut. Shafer in command of one detachment and Lieut. Willard in command of the other. With Lieut. Shafer were Lieuts. Loughran, Sheldon, and Chandler; and with Lieut. Willard were Lieuts. Benedict and Loughlin; while Capt. Stickney maintained liaison between Third Army Headquarters and the two detachments.

The route of the first detachment was as follows:

November 17 — Haudiamont.
18 — Etain.
19 — Piennes.
20 — Audun-le-Roman.
21 — Bettemburg (Grand Duchy of Luxemburg).
22 — Wormeldingen.

At Wormeldingen (or Wormeldange) the detachment rested until December 1, having a reasonably good time. Of course we had drill, but after drill one could easily exchange a loaf of bread

or a piece of soap for *beaucoup* "*schnapps*." It is said that a cake of soap or two loaves of bread was good for three months' lodging. No wonder we ran short! On December 1 this detachment crossed the Moselle River into Germany and marched to Wirges, billeting overnight in the following towns:

December 1 — Wawern.
2 — Gasel (passing through Trier).
3 — Mehring.
4 — Trittenheim.
5 — Zeltingen.
6 — Enkirch.
7 and 8 — Briedel.
9 — Leisenich.
10 and 11 — Morshausen.
12 — Lay.
13 — Coblenz.
14 — Wirges (crossing the Rhine at 7 A.M.).

On the 16th the detachment was relieved from duty with the 1st Engineers and returned to Coblenz (Neuendorf).

The second detachment followed the route indicated below, billeting at the towns named:

November 17 — Manheulles.
18 — Jeandelize.
19 — Briey.
20 — Rosslingen.
21 — Beauregard.
22 — Kechingen.
23 to December 1 — Evange.
December 1 — Kirf.
2 — Hentern.
3 — Rinefeld.
4 — Idar Brück (the night spent in the pine woods, where each man cooked his own supper).
5 — Hottenbach.
6 and 7 — Manhausen.
8 — Argenthal.
9 to 14 — Bacharach.
15 and 16 — Overspay.

The two detachments were reunited at Coblenz (Neuendorf). Our hike was a long one, but now that it is over we are glad we had it. The reception we got from the German people was very

good. Naturally it would be — they are not all fools. Even though we knew they hated us, it was more pleasant to be received with smiles, "*Moselwein*" and an open house, than to have them show their real feelings. No, we have no fault to find with their hospitality, even though it was forced. One feature of German *Kultur* that we saw was the great number of children. Every village had droves of them between the ages of *one* and *four* years.

The country traversed during the march was beautiful, and the temperature ideal for hiking. From Ancemont we started out with full packs, but from Dieue our trail was marked, first by souvenirs, then by those useless condiment cans, and finally by underwear and even guns — everything one could possibly do without. The first night spent in Luxemburg (especially for the detachment at Bettemburg) was large and glorious. We were the first American soldiers the inhabitants had seen, and we were hailed as "deliverers." Jimmy Conn was quite the hit of the evening at the dance given in our honor at Bettemburg. Jimmy looks very well in a high silk hat and a frock coat. Resounding bumps and thuds were heard as some of us alighted from the water wagon.

The 19th of December Company C entrained at Coblenz and proceeded to Sorcy-sur-Meuse by way of Metz. We had with us two German boys who said that they were going to America also. One of them got as far as Bourg, but there he was arrested as an enemy and sent back. Sorcy, you will remember, is the town where "Scotty" sprained his ankles when he tried to convince a husky buck private that Company C had done more to win the war than many divisions. The billets at Sorcy were the worst we ever had. After real beds in Germany, or at least a dry, warm floor, the cold barns with their soaking wet hay were awful. We won't say anything about the Christmas dinner we had. The sooner it is forgotten, the better!

Monday, the 30th, Company C, together with the rest of the regiment, entrained for Bordeaux, under orders for embarkation to the United States.

The following men of Company C received commissions as second lieutenants: Private First Class Robert L. Weed, F.A.; Sergt. Howard G. Sheldon, Engineers; Sergt. David S. Thompson, Engineers; Sergt. Homer E. Young, Engineers; Sergt. Frazee J.

Young, Engineers; Sergt. Robt. V. Chandler, M.T.C.; Sergt. L. V. Ellingsworth, Engineers; Sergt. First Class Lucien G. Hughes, Engineers; Sergt. James E. Blake, Engineers; Private First Class Royal N. Howard, Engineers; Sergt. Matt Finger, A.S.C.

WATER-PURIFICATION TRUCK (" STERILAB ").

Pumping and filtering equipment in rear, chlorination equipment in center, and laboratory space in forward portion of housing.

LOOKING INTO REAR OF WATER-PURIFICATION TRUCK (" STERILAB ").

Pressure filter tank at left.

COMPANY D.

Company D, 26th Engineers, was the fourth company of the Regiment to be organized. It had its origin in what was known as the " Casual Company," formed December 10, 1917, from enlisted men initially attached to Company C, 26th Engineers. Capt. Oliver F. Allen was assigned to command this Casual Company, aided, from the 21st of December, by 1st Lieut. Ralph Neufeld, who was temporarily on duty with the Company. At first the organization had a strength of about 125 men, all voluntarily enlisted and recruited in large part from the oil fields of California. On December 21, 1917, this Casual Company was officially designated as Company D, 26th Engineers, and on January 6, 1918, Capt. (then 1st Lieut.) John C. Pritchard was placed in command, with 1st. Lieut. Fred S. Wells and 2d Lieuts. Raymond Foulkrod and Glenn R. Stevens as the first regularly assigned officers. Lieut. Neufeld was at the same time relieved from further duty with the Company.

In passing through the various stages of military training, the organization encountered more than the usual difficulties. For over six weeks the Company was in quarantine because of the prevalence of measles, and, in addition, had to contend with the discomforts of an unusually severe winter. But the officers were always well seconded by the never-failing good spirits and hearty coöperation of the men. Early in January a school was started, under the direction of Lieut. Pritchard, for candidates for positions as non-commissioned officers. Great interest was manifested in this school, and much excellent material was developed. " Sergeant Hill " was chased all over the battlefield of Gettysburg by these embryo tacticians, and rescued from many embarrassing situations.

Practical military instruction was given to all the men every day, beginning with the school of the soldier and continuing through the school of the squad, platoon, and company. Company athletics were also very popular. A very successful baseball team was organized, under the leadership of Sergt. Roth.

On January 25, 1918, 2d Lieut. James R. Rosenfeld was assigned to the Company. Other changes in the commissioned personnel about this time were as follows: 1st Lieut. John C. Pritchard was commissioned captain February 14, 1918; Capt. (then 1st Lieut.) T. B. Parker attached February 11, 1918, and assigned February 20, 1918; 1st Lieut. F. S. Wells transferred to duty with Company C, February 20, 1918; 1st Lieut. Harvey T. Munn assigned to the Company February 17, 1918. In the meantime the number of enlisted men was steadily increasing until on February 20, 1918, there were, assigned and attached, approximately 320 men. Eighty-five of these men were transferred to become the nucleus of Company E, leaving about 235 men in the organization, which number was later reduced by transfers to about 200 men. Company D was then again gradually built up to strength.

During this period each man was taught the care and nomenclature of the rifle, and was also required to pass a series of tests in sighting and aiming, assembling, loading, and firing his piece. At the completion of these tests the Company spent a total of six days on the rifle range.

About this time another series of changes took place among the commissioned personnel, from which the Company emerged with the officers who took it overseas. These changes were as follows: 1st Lieut. Gash was assigned to the Company May 11, 1918, relieved May 19, 1918; 1st Lieut. H. T. Munn relieved from further duty May 11, 1918; 1st Lieut. R. P. Hastings assigned to the Company May 19, 1918; 2d Lieut. R. Foulkrod appointed supply officer of Company May 11, 1918, and commissioned first lieutenant May 23, 1918; 1st Lieut. William C. Colgan, Sanitary Corps, attached to the Company during the month of April, 1918. This left the Company with the following officers: Capt. John C. Pritchard, 1st Lieut. Russell P. Hastings, 1st Lieut. Theodore B. Parker, 1st Lieut. Raymond Foulkrod, 2d Lieut. James R. Rosenfeld, 2d Lieut. Glenn R. Stevens, 1st Lieut. William C. Colgan, Sanitary Corps (attached).

Regimental Headquarters and Company D left barracks at Camp Dix for overseas at 12.30 A.M., June 22, 1918, entrained at the Camp Dix railroad station, arrived at Hoboken about seven

o'clock the next morning, and boarded the transport *President Grant* the same day at noon. That afternoon the ship dropped down the bay, but trouble soon developed in the refrigerating plant and she returned next day to the Hoboken docks. The Company disembarked and proceeded by ferry and train to Camp Mills, Long Island. Here it remained a long week, but reëmbarked on the same vessel June 29 and finally left port on the 30th.

The weather on the voyage was delightful. Fifteen transports with 1 cruiser and 4 destroyers started the voyage together. Later, a transport caught fire and another, with 2 destroyers, dropped back to give her aid, so that finally only 13 transports, 1 cruiser, and 2 destroyers remained in the convoy. Two days out from Brest the convoy was met by 11 more destroyers, and on the evening of July 12 Brest Harbor was entered, — the transports in single file, with a line of destroyers on either side. It was a sight never to be forgotten.

On the way across the ocean the men of Company D drew the delightful task of acting as mess attendants and guardians to about 2 500 gentlemen of color, fresh from the cotton fields of Alabama and Louisiana. For the first time, it was realized that "the Army is democratic." Drills for "abandon ship" were held each day, and once within the danger zone every person on board ship had to be at his "abandon ship" station from 2.30 A.M. until daylight.

The Company debarked the morning after making port, and marched to Pontanezen Barracks, the so-called "rest" camp. Four days later it entrained for Baccarat on the French front in the Department of Meurthe-et-Moselle, in response to a call for water-supply troops to serve American divisions operating there with the French. After four days and nights in French box cars (each posted to carry "8 horses or 40 men"), the Company detrained and went into billets in the small town of Deneuvre, just across the Meurthe River from Baccarat. Here the first taste of war was had when the town was bombed on several occasions by German planes.

Before the Company got to work in the Baccarat sector, a still greater need arose for water-supply troops in the Château-Thierry sector, where the III U. S. Corps was operating as a part of the French Sixth Army. While these matters were being straightened

out at First Army Headquarters, the Company remained at Deneuvre in comparative idleness for over a week. Finally orders were received to move again, and after a tiresome journey lasting three days and nights the outfit detrained August 4, at Nanteuil-sur-Marne, 20 kilometers downstream from Château-Thierry. Since the railroad line direct from Baccarat through Nancy to Château-Thierry along the Marne River had recently been cut by the enemy, it was necessary to take a more round-about route through Paris. This made it possible to see a little more of France, but all that was visible, from the railroad yards at the eastern edge of Paris, was the top of the Eiffel Tower.

On August 8 the Company was marched out of Nanteuil-sur-Marne, along the north bank of the Marne, and camped for the night at Gland, just above Château-Thierry. On the following day, Fere-en-Tardenois was reached. This was the first march of any extent the Company had taken in France and it left many men, and some officers, with sore feet. At Fere-en-Tardenois the Company was split into two detachments, Lieuts. Parker and Rosenfeld with 100 men going to Coulonges, while the remainder went to Sergy under command of Capt. Pritchard.

This entire area had very recently been vacated by the enemy, who, at the close of the great Château-Thierry counter-offensive, had been driven back from the Marne to the line of the Vesle. The region was thoroughly devastated. Here, therefore, was actually begun the work for which the Regiment had been formed, namely, that of supplying water to troops at the front. Water was found to be very plentiful, but it was necessary to safeguard it against contamination and to make it available for both men and animals. Repairs were made to the water systems of ruined villages, and also to French Army water points, installed previous to the German drive and subsequently destroyed. New sources of supply were developed where necessary, points for filling water carts established along the main roads, watering troughs built, wells cleaned and repaired, and pumps installed.

The Company was now attached to the III U. S. Corps, and accordingly came under the authority of the Corps Engineer. However, since this Corps operated tactically under the French Sixth Army, much of the work was carried on under the direction of

Lieut. Bonnevalle of the "Service des Eaux," who commanded a detachment of French Army water-supply troops operating in the same territory. It was really Lieut. Bonnevalle who introduced the Company to the World War, and the ceremony could not have been placed in better hands.

Meanwhile a call for more water-supply troops had come from American First Army Headquarters, which had meanwhile been shifted from La Ferté-sous-Jouarre on the Marne to Neufchâteau (Vosges), for plans were already being made for an attack on the St. Mihiel salient. Orders were received for one half of Company D to move to the Toul front as rapidly as possible. Hence August 20, 1918, Lieut. Stevens was transferred to the 2d Detachment, under Lieut. Parker, and on the 21st, at 2.30 P.M., Capt. Pritchard, with Lieuts. Hastings and Foulkrod and 130 men, left Sergy in trucks. On reaching Pagney-sur-Meuse, Lieut. Hastings was ordered to special duty under the Water Supply Officer at First Army Engineer Headquarters and never rejoined the Company. The remainder of the detachment reached Griscourt at 11.00 P.M., August 23, and started work the next day on a 5-kilometer 4-in. pipe line, to furnish water to troops in the Forêt de Puvenelle, which was at that time being used, because of the concealment offered, as a concentration point for troops in preparation for the St. Mihiel drive.

One hundred men of Company A and 150 men of Company B, 27th Engineers, together with 75 men from Company E, 26th Engineers, were attached to the 1st Detachment of Company D, making a total of about 450 men under the direction of Capt. Pritchard. Water points were installed throughout the forward area, to take care of the tremendous concentration of men and animals. The men worked with the greatest willingness, night and day. They were under intermittent shell fire from the German batteries, but luckily no casualties resulted. By the time of the St. Mihiel drive, on the morning of September 12, the water-supply situation of the sector had been vastly improved.

Four advance parties, of 20 men and one wagon each, were started out the morning of the "drive," to follow the infantry advance and do everything possible to supply water within the captured territory. The transport for these parties had to be

4-IN. PIPE LINE BEING INSTALLED IN CONNECTION WITH FOREST OF PUVENELLE SYSTEM.

The earlier pipe lines of this system outside of the forest, and installed in preparation for St. Mihiel offensive, were not buried. Ditching would have been a tell-tale to Boche aviators.

obtained from one of the French auxiliary services, whose personnel was made up entirely of old men. The two-wheeled French carts with spreading sides were anything but the proper sort of conveyance for the tools and rations, but they were the best that could be had at the time. When the cart was in working condition the horses or drivers were not, and vice versa. Altogether they were a source of much amusement to the men, and an account of the accidents to them would fill many pages. However, valuable work was accomplished by these advance parties, including the installation of canvas reservoirs to be filled by tank trains and the repair of the water systems of Thiaucourt and other recaptured villages.

Hardly had the St. Mihiel attack ended, and hardly had the organization of the captured area been begun, when the 1st Detachment, and in fact, both detachments, of Company D were in demand in an area miles distant. For the Boche was to be given no rest, and the American First Army was to strike in the entirely new Argonne-Meuse sector — new from the viewpoint of occupancy by American troops. And this attack must needs be made within two weeks after the beginning of the St. Mihiel drive! So it was that on September 17 the entire 1st Detachment was reassembled and on the evening of the 18th departed by motor truck for the Argonne-Meuse front. Traveling only at night to avoid detection by hostile aëroplanes (for the large troop movement had to be made as secretly as possible), the detachment arrived at Jouy-en-Argonne at midnight of the 19th. There the men were surprised to find awaiting them their fellows of the 2d Detachment, from whom they had parted in the Château-Thierry sector.

While the 1st Detachment was in the St. Mihiel sector, the 2d Detachment was having varied experiences along the line of the Vesle. It maintained headquarters in some old French barracks at Coulonges, but occasional attentions from hostile planes and batteries forced it to sleep in dugouts in a nearby hillside. Working parties were sometimes under shell fire, but fortunately no one was hurt. This detachment remained in the sector for one month and established semi-permanent water points for men and animals as far north as Chery-Chartreuve and Courmont. Orders were then received to move with the III U. S. Corps to the Argonne-

Meuse front, and on September 11 the detachment entrained at Dormans, on the Marne. Detraining at Souilly (Meuse), near Verdun, September 12, at 3.00 A.M., the detachment marched a few kilometers north and went into camp near Lempire.

The detachment was then detached from III Corps and directed to report to Chief Engineer, American First Army. Some difficulty then arose in securing definite instructions, but on September 16 Capt. F. W. Scheidenhelm, as Water Supply Officer, First Army, appeared with orders for the command to move to Jouy-en-Argonne. Setting out shortly before midnight, this destination was reached before daylight the next morning.

After the arrival of Capt. Pritchard with the 1st Detachment during the night of September 19, the whole Company moved to some old French gun emplacements near Dombasle-en-Argonne.

Preparations were at once made for supplying water to troops and animals, before and during the expected Argonne-Meuse offensive. Although now operating as army troops, the Company sector remained approximately that of the III Corps and extended along the front for about 10 kilometers west from the Meuse River.

While waiting for Company F to arrive from the St. Mihiel front, 90 men under Lieuts. Parker and Rosenfeld were sent to Auzéville to start the work in the district or sector (on the left) assigned to Company F. These men had rather a stiff time of it. One detachment of 16 men, under Corp. LeGrand, was on duty in the Forêt de Hesse for seven days and nights with very little to eat.

These detachments had nearly all returned to the Company by September 25, when 4 advance parties of 20 men each were formed to follow the infantry attack, which was to take place the next morning at daylight. These 4 parties were commanded respectively by Lieuts. Parker, Rosenfeld, Stevens, and Sergt. First Class Taggart. Each party was equipped with an escort wagon drawn by 4 mules; all left Company Headquarters during the afternoon of September 26, 1918.

The parties camped the first night at Montzéville, and the following morning each party advanced toward its respective portion of the Company sector. In order to accomplish this it

was necessary to cross the strip of country which had been laid waste by the previous four years of hard fighting north of Verdun. This area included such historic localities as Hill 304 and " Le Mort Homme " (Dead Man's Hill) and was pitted and furrowed to an unbelievable extent. This old No Man's Land had been crossed by our infantry the previous day and was now securely held. After great difficulty the four parties finally emerged beyond the old German trench systems and took up positions from which they could work throughout the country behind the front line. Lieut. Stevens located at a point on the former Forges-Bethincourt road, Lieut. Rosenfeld at Bethincourt, Lieut. Parker near Gercourt, and Sergt. Taggart near Cuisy. Lieut. Rosenfeld subsequently moved up to a point west of Gercourt.

The next few days were spent by the advance parties in an endeavor to develop such water points as would most quickly supply the immediate demands of nearby units. Gasoline-engine-driven pumps, hand pumps, elevated tanks, and canvas reservoirs were used at various places. Where no local source of supply was found, water was hauled from the rear in motor tank trucks. Mobile purification trucks were also used to good advantage, and where possible they were later replaced by semi-permanent installations. The first complete water points were established at Bethincourt and at Moulin de Rafficourt, between Bethincourt and Forges. These water points comprised gasoline-engine-driven pumps, elevated steel tanks, automatic chlorinators, cart-filling stations, and horse-watering troughs. They were used very extensively, that at Bethincourt furnishing a daily average of 20 000 gal. for a period of more than a month. Similar water points were later established at Cuisy and Septsarges.

All supplies, rations, etc., were sent to the advance parties by trucks from Company Headquarters. The roads were almost impassable, and often were blocked by traffic. It required hard work on the part of the drivers to keep their trucks moving. Sergt. First Class Fadler personally conducted most of the supplies through the wilderness of poor roads and traffic, and Sergt. First Class Roth was responsible for keeping the trucks in operation.

Meanwhile the infantry had fought their way across the Meuse River and had obtained a foothold on its eastern bank. Hence

on October 10 Lieut. Parker and a few men crossed the river at Consenvoye and established themselves in dugouts on the bank of the canal near Brabant. Here they were joined by a detachment from Company C under 1st Lieut. Fred S. Wells, and immediately started work. A mobile purification truck was moved into Consenvoye, but damage by shell fire soon caused its removal.

Company Headquarters were moved to Bethincourt, October 12, and established in a dugout hidden in the ruins of the village. About this time Company M of the 59th Pioneer Infantry (a former neighbor at Camp Dix) was attached to the Company, bringing the total strength of the command up to approximately 500 men. The Pioneer Infantry was used mainly on ditching and paving, thus releasing some of Company D's skilled men from the pick and shovel.

On October 18 Capt. Pritchard was transferred to Company E, then operating in the Argonne Forest, and Lieut. Parker was recalled from across the river to take command of Company D. Lieut. Rosenfeld took over the territory east of the Meuse. Sergts. First Class McCormick and Hamilton left for Officers' Training Camp, and Sergt. Fabian and Corp. Klann to attend Gas Defense School.

On October 26 Company Headquarters were again moved, this time to German dugouts in the Bois de Forges. By this time there were only two advance parties in the field, one under Lieut. Rosenfeld on the east bank of the Meuse, and one west of the river under Sergt. Taggart. The latter was preparing to follow the next drive northward.

Thus far, the good luck of the Company had been remarkable, but on October 27 Sergt. Taggart reported that five men of his party had been wounded the day before, by a high-explosive shell, near Nantillois. These men were Sergts. Bustard and Green, Privates First Class J. B. Pelphrey and F. C. C. Johnson of Company D, and Wagoner Metzger of the 1st Engineer Train. Privates Pelphrey and Johnson died from their wounds, October 28. On that day, also, a German shell made a direct hit on the cooks' dugout at the headquarters camp in the Bois de Forges, and Cook Prezlina and Privates Garhartt and Panell were wounded. Cook Prezlina, though painfully hurt himself, insisted that Garhartt be

taken care of first, and did everything in his power to aid him. All these men were sent to the hospital. Shortly afterward, Cook Colby and Privates Foulke and Barrett of Lieut. Rosenfeld's party were taken to the hospital suffering from the effects of gas. Company M of the 59th Pioneer Infantry had one man killed and eight "gassed." All of these were attached to the party operating east of the Meuse.

Meanwhile the water-supply work was progressing. East of the Meuse the territory in which it was feasible to work had been very narrow, and the first water points to be established were near the river and temporary in character. Most of these were later supplemented or replaced by semi-permanent gravity filling stations. Tank trucks were used to distribute water to points not served directly. West of the Meuse, points previously established were maintained and improved, and water was supplied to the Bois de Forges from the old German pumping station at Gercourt.

On November 5 the stubborn German resistance broke, and our infantry advanced so rapidly that it was almost impossible to keep up with them. Company Headquarters were moved to Liny-devant-Dun on November 9 and remained there until the Armistice. Some permanent water points were installed in the "jumping off" area for the Army of Occupation, and the city water system at Stenay was repaired and put into operation. Water points that had been installed for use during the Argonne-Meuse offensive were salvaged. The work of salvaging this material along the whole front formerly occupied by Companies D, E, and F was begun by Company D on November 21 and completed within two weeks.

Along the reconstructed standard-gage railroad running north from Verdun, detachments from Company D also constructed a series of 12 locomotive-filling stations, extending from Charny to Sedan. These were all installed in advance of the railroad construction. This work required the placing of parties along the whole line, and as a consequence the Company was for a short time widely scattered.

After the conclusion of this work the Company was assembled at Liny, and just before Christmas moved to Verdun. While at Verdun two very regrettable accidents occurred, one to Wagoner

Peterson who was hurt in a motorcycle collision, and the other to Private Capoots who was badly injured by the explosion of a one-pound shell.

While at Liny-devant-Dun, the following additional officers were attached to the Company: 2d Lieut. D. S. Thompson, Engineers, promoted from sergeant first class, previously with the Company C detachment at Brabant; 2d Lieut. F. B. Barns, Engineers, promoted from master engineer, junior grade; 1st Lieut. Wagner, Sanitary Corps, temporarily attached from 301st Water Tank Train; 2d Lieut. W. R. Schoonover, Sanitary Corps, promoted from sergeant first class, Sanitary Corps.

Throughout the work along the Meuse, Lieut. Colgan was sanitary officer for the Company, and was responsible for the treatment of all doubtful water. Under his direction Lieut. Schoonover operated the field laboratory and made water analyses, etc. Lieut. Foulkrod, as before, continued his work as supply officer and Company adjutant.

On the 31st of December the Company entrained at Verdun, and on January 2, 1919, arrived at Bourg-sur-Gironde to await transportation back to the United States. By this time the strength of the Company had been reduced to about 220 men, 10 of whom were on detached service.

In conclusion, it may truthfully be said that a more loyal and willing body of men it would be hard to find than Company D, 26th Engineers. For almost four months they were continuously at the front, without one day of rest in the entire period, and working and living under conditions almost identical with those under which the divisional engineer troops work and live, whereas the divisional troops do have rest periods. Everybody did his bit cheerfully and willingly, and to this spirit is due in a large measure the surmounting of what at times appeared unsurmountable difficulties.

COMPANY E.

Company E was organized on the 18th of February, 1918. Its growth was rapid, having as a nucleus 14 men from the old Specialist Detachment, 26th Engineers, and 80 men assigned from Company D. With this body of men, Capt. Arthur Knapp and Lieuts. Frank T. Gash, M. M. Maneese, D. M. Forfar, E. M. McCutcheon, and F. C. Sellnow began evolving an efficient military organization. They had to deal with raw recruits and inclement weather, but, notwithstanding these conditions, and the fact that the number of recruits was ever increasing, it was a well trained organization of 241 men that left Camp Dix, together with Company F, early on the morning of August 17, 1918. The personnel of the officers remained the same with the exception of Lieut. Maneese, who was transferred to the 54th Engineers, and Lieut. McCutcheon, who was replaced by Lieut. Harry Angell.

The men as they marched to the train, and later as they sat in the coaches waiting to move, exhibited a spirit of enthusiasm which, though it was sincere, was tempered with a shade of fear lest the " deck contain a joker " in the form of a sojourn in some other camp before sailing. This doubt was not wholly dispelled until the two companies were given their respective jolts of real Red Cross coffee at the Brooklyn pier and marched up the gangplank of the Cunard liner *Italia*.

Beside Companies E and F of the 26th Engineers, the ship carried about 600 Signal Corps recruits, " corn crackers " from Arkansas and Missouri, who, due to the fact that they were the direct product of a draft board and had had all of several weeks' military training, held themselves in a spirit of superior aloofness. This engendered no small amount of contempt in the minds of the 26th " vets," and this contempt was in no way lightened by the fact that the " corn crackers " were always first in the mess line.

In the effort to obtain gastronomic satisfaction in the form of doubtful eggs and saltless spuds, served to the monotonous chant of the cockney steward of, " Kie pays, only one piece of bread to

the mon," and, "Hurry by, men!", it was necessary to file past the galleys, wherein was being prepared the food of the officers' mess. How well the emanating odor of crisp bacon and "French fried" blended with our memories of home and mother's cooking! It's easy to understand why the British Colonial insists that he's British and not English. As for that steward, "God made him, and therefore let him live."

The trip across the Atlantic, aside from the above and a few other petty annoyances, was rémarkably successful as well as uneventful. Better weather and a calmer sea could hardly be imagined, and from the standpoint of a sea voyage it had a "Cook's Tour" backed off the map. Gambling on board ship was strictly prohibited, hence craps and poker were the popular pastimes.

It was a great relief for every one after fourteen days of seeing the wet side of the world, to again sight land, and Wales at that. To those men from the Nevada, California, and Arizona deserts, the jagged contour of old Wales brought thoughts of home. On the 31st of August we landed at Liverpool at about 9 A.M. After getting sea legs accustomed to solid foundation and eyes accustomed to the different scenery, and after drinking several mugs of Lipton's best coffee served by the British Red Cross, the members of the Company entrained for Southampton. The trip, requiring about eight hours, was one of the most pleasant that many had ever experienced. There was mile after mile of green, broken only by the stone fences which seemed to have no direction or reason for their existence, other than a place to put the stones. Quite in contrast with this, were the cities and towns along the way, where one saw blocks of red tile houses, symmetrical in every respect and almost monotonous in their sameness. Throughout England the absence of able-bodied men was very noticeable. On all sides the women and old men gave assurance that Kaiser Bill's finish wasn't far off then.

Arriving at Southampton, the Company marched several miles to an English rest camp, which seemed to be operated by American Jackies. The following morning the men had their throats examined and left at 2.30 P.M. for the dock, at which the Company embarked on a speedy little steamer for Le Havre. The comforts offered by this boat were similar to those offered by sardine cans

except that the oil was lacking. Nevertheless, it was a ride worth the money. Le Havre was reached about 3.30 A.M., and the Company disembarked at 8 A.M. The camp to which the men were marched, from the standpoint of a landscape artist, was ideally located, as it overlooked the major part of the city and harbor. From the standpoint of a buck private, however, with a rifle and 70-pound pack, it made him wonder what some of the real horrors of the war were like.

Upon arriving at the so-called "rest camp" the men were assigned to conical "squad" tents, 12 men to the tent. Then did the short man come into his own. The six-footer had his troubles, for he could neither stretch out nor curl up. The stay at this camp was devoid of any pleasure except that derived from eating smoked herring and drinking tea and watching the German prisoners amuse themselves on a trapeze and horizontal bar inside the prison camp, while the members of the camp qualified as guests of the British by making little rocks out of big ones along the roads outside the fence. No passes to the city of Le Havre were allowed.

On September 3 there was the customary inspection of quarters and equipment by a British colonel. On the following morning packs were rolled before breakfast, and, after loafing around all day, the Company made a three-mile hike to the station and was loaded into French box cars, 30 men to the car, each car containing three days' rations. Every one understood that this was the last lap of the journey and would end somewhere near the front. The men were more or less eager to get back into the little four-wheel cages after the sportive frolic at the rest camp.

At Neufchâteau, Companies E and F parted, Company F going to Sorcy (Meuse) and E to Pompey (Meurthe-et-Moselle), at the junction of the two rivers, where it arrived at 9 A.M. The men loafed around near the station at Pompey for the remainder of the day. No one seemed to know why they were there, and no small degree of unrest was caused by signs posted everywhere ordering gas masks to be worn in the alert position. That apparently did not apply to the members of Company E, however, for they had neither gas masks nor steel helmets. About dusk the order was given to sling packs, and the Company marched about a half mile

north of the town, where " pup " tents were pitched for the night.

It was here that the rumble of the artillery was heard for the first time, coming from the general direction of Metz. After two days the Company moved into billets in the town, and the men spent their time fixing up the kitchen and policing up around the billets. Several bloodless battles with John Barleycorn's European allies were fought and won here in Pompey. The chief items of interest, aside from the good beer that could be purchased in town, were, the aëroplanes that were continually tempting the loçal anti-aircraft batteries, and the employees of the big steel plant, who were mostly buxom lassies clad in bloomers.

The realization that a war was in progress was forcibly driven home a few nights after arriving in Pompey, by a Fritz airman who, after taking a few practice shots at the steel plant, pulled the end gate and went home. It seems that the Fritz airmen had a habit of following up the Moselle River every night, except the very brightest moonlight nights, and dropping samples of their wares whenever the spirit moved them. It was surprising what comparatively small damage those bombs did, although it seemed to every one, from the jar and noise of their explosions, that there couldn't be much left of the plant. About the only protective measures taken against these raids were the shutting down of the machinery and causing a smoke screen to envelop the plant. The approach of a plane was announced by means of a siren. A single blast certainly moved the natives to hunt their dugouts, and it was not long before every one in the Company learned to follow them. The victims of these raids were mostly women and children working at the plant.

A few days after the arrival at Pompey, Capt. Pritchard, then of Company D, appeared with an order calling for a detachment from Company E. Lieut. Sellnow and 75 men were detailed, and assisted Company D as water guards during the St. Mihiel drive, where some real action was seen and experienced.

On September 10 Lieut. Sellnow and men arrived at Griscourt, where they spent a few days getting acclimated. On Friday, the 13th, Lieut. Sellnow and 15 men from the 26th and 27th Engineers, with a French cart loaded with water-supply material, started out for Bois de Four, about 5 kilometers south of Thiaucourt. The

Bois de Four was well beyond what had been the German front-line trenches, and the reverse slope of the hill had been a favorite place of residence for the Germans for four years, being honeycombed with dugouts. The objective was finally reached, but none of the party, as they look back upon the traffic jams and steep, sloppy hill of Regniéville, can figure out just how they did it. The Regniéville-Thiaucourt road connecting with the Paris-Metz highway passed through what had been No Man's Land for four years. The German positions were a labyrinth of trenches and a maze of barbed wire, and through the village of Regniéville the road was absolutely non-existent. By the following evening, the reservoirs, located as they were, just ahead of the heavy artillery, had been completed, a water train had arrived, and the Water Service was functioning. These reservoirs were located in a wooded section, which, according to high authority, was scheduled to be blown off the map by the Germans most any old time. With this thought ever present in their minds, the feelings of the men can easily be imagined, when they were suddenly raised off the ground by the report of a battery of 6-in. howitzers situated in the nearby woods. Lieut. Sellnow and 8 men left the main detachment in the woods and proceeded to Thiaucourt. Here an investigation of the city water system was made and the damage done by the retreating Germans repaired.

It was about this time that Sergts. Baker and Gingrich, in charge of the detachment assisting Company D, chafing under the restraint imposed by their responsibility, threw restraint and discretion aside and decided to see a little of the war themselves. Leaving the "gang" in charge of corporals, and with no little lateral play in their knees, they started out in the general direction of the front. Their indomitable courage and strategic ability were rewarded by what was probably the first important capture accorded to Company E. Without shedding a drop of red blood, these two men captured, single-handed, one German canteen filled with a Milwaukee odor.

On September 17 the Company was reassembled at Pompey, and that same night left in Mack motor trucks for Les Islettes-en-Argonne, traveling by night in the rain and sleeping by day. They arrived at Les Islettes early on the morning of September 20.

Here they rolled in for the remainder of the night in some deserted buildings. One experiences rather a creepy feeling when ordered to wear a gas mask in the alert position, at the same time being forbidden to light even a cigarette, when he can neither hear nor see anything to cause alarm. The men found out, the next morning, that they were among the very first American soldiers in that town, and were only 5 miles from the front-line trenches.

This sudden shift from Pompey to Les Islettes was a great experience for all who took part in it. The American First Army, under which all of Company E's work was performed, immediately after the successful St. Mihiel offensive, was shifted across the area west of Verdun, the troops, guns, and trucks moving at night. Only " holding " troops were left on the scene of the St. Mihiel drive. The result of the secrecy with which the move was completed was apparent in the complete success of the ensuing offensive. There is probably no question that the Germans knew an offensive was coming, but they were utterly unprepared for an attack of the magnitude which developed, and at so early a date.

A few days after arrival at Les Islettes, the Company having been assigned to Les Islettes district corresponding with the I Corps area, 4 advance parties were equipped and sent out to follow the impending drive and establish the necessary water points. Each party consisted of 1 lieutenant and 20 men. One of these parties followed up the valley of the Aire River, one along the ridge of the Forêt d'Argonne, one in the valley of the Aisne, and the fourth on the hills east of the Aisne. These parties remained in the field practically without relief for 49 days, establishing water points, investigating water of doubtful sources, and, in general, doing everything within their power to keep the doughboys from getting thirsty and the guns from getting too hot.

The work of the pioneer parties was arduous and not without hazard. Their task was that of performing skilled labor in the territory which received the full benefit of the German back-area shelling, without protection and without the excitement and satisfaction of striking back. The party in the Aire Valley and on the hills to the east followed up the 42d and 35th Divisions in the hard fighting that resulted in the capture of Varennes, Cheppy, Charpentry, Fléville, and Exermont, the latter being a particu-

CART AND TANK TRUCK FILLING STATION AND ANIMAL WATER TROUGH AT APRÉMONT.

Supplied from 1 350-gal. steel tank on tower, filled with chlorinated water by gasoline engine-driven pump from Aire River; rock-paved turnout for carts and animals. (Argonne-Meuse offensive.)

larly unhealthy spot. The party in the Argonne Forest had a different condition to meet. The topography of that portion of the forest north of Les Islettes is in general a ridge or backbone which carries the main road through the forest in a generally north and south direction. Very deep ravines, with exceedingly steep sides, lead away to the east and west of the ridge. Water was abundant in the ravines but very scarce on the ridge, and the mission of this party was to make water accessible to the ridge road, which they succeeded in doing. Most of the service in this sub-area was for the benefit of the 77th Division.

Great difficulty was experienced in rationing these pioneer parties from Company Headquarters. The Company transportation was meager, consisting of four motor trucks which had an annoying habit of all breaking down at one and the same time. Continual rain through October made travel through the forest a matter of great difficulty, while the congestion of traffic on the roads east and west of the forest made a day's work out of a journey of a few miles. Consequently, it took at least two days to carry food to all of the parties and water guards. However, the pioneer parties proved capable of taking care of themselves, and, at times, when the Company ration trucks were delayed, " rustled " rations from the nearest organization. Divisions were uniformly generous to the pioneer parties, upon learning the nature of their work. They were ready to swap " bread " for water.

Though it may not seem so to the reader, it is nevertheless true that one of the most provoking things the pioneer parties had to put up with was the transport furnished. This, in nearly all cases, consisted of a strong, heavily built combat wagon and a dandy set of 4-up harness. More to keep this harness from dragging than for any other reason, four little hybrids, resembling Jersey mosquitoes in build, were furnished for each wagon. Their capacity for hay soon proved to be greater than for work, and in negotiating even the slightest grade it was usually necessary to add ten to twenty units of man power. In this manner the men followed the drive across No Man's Land.

The parties were continually under shell fire, but, due to luck more than anything else, losses were confined for the most part to animals and equipment. On October 10, Corp. S. K. Smith

was killed, and Privates Teeple and McLoughlan were wounded, by the explosion of a German slow-fuse mine in a little valley near Châtel. Three days later, Private Olson was severely wounded by shrapnel at La Besogne Farm, near Marcq. These men were all from the party of Lieut. Sellnow. A few days later, Private Elmer E. Garner, of Lieut. Forfar's party, while installing a canvas tank at Epinonville, was wounded in the head by a piece of shell.

On the 14th of October, Headquarters moved from Les Islettes to a wooded crossroads west of Varennes, known as "Abri du Crochet." Five days later Capt. Knapp was relieved from command of Company E and Capt. John C. Pritchard, transferred from Company D, was put in command. Meanwhile the pioneer parties followed close behind the drive at all times, and sometimes too close for real comfort. Working out from Abri du Crochet, permanent water points were constructed at La Chalade, Varennes, Cheppy, Charpentry, Abri du Crochet, Aprémont, Fléville, Exermont, north of Cornay, Lançon, Grandham, two points on the right of the Forêt d'Argonne, and one point in the old No Man's Land in the Argonne (for filling locomotives on the narrow-gage railroad). In addition to the above, mobile purification trucks were operated at Varennes, Cheppy, Charpentry, Aprémont, Fléville, Vienne le Château, La Harzée, Lançon, Châtel Chehery. Some of these were later replaced by permanent installations consisting of power pump, tower, and tank.

On October 27 the Company Headquarters were moved forward to Châtel, and on November 5 to Buzancy. Meanwhile three of the pioneer parties continued to follow the advance in the new Argonne-Meuse offensive. Owing to the rapidity of this advance, the work consisted mainly of reconnaisance and the transmission of water information. The parties worked as far forward as Angécourt near Sedan, covering an area from a line from St. Juvin to Grand Pré, to a line from Chemery to Angécourt. These parties were recalled on November 15. Semi-permanent water points were installed at Buzancy, Sommauthe, Fossé, and St. Juvin. Railroad filling stations on the Varennes-Grand Pré Railroad were installed at Varennes, St. Juvin, Marcq, and Grand Pré. Preparations were made, just before the Armistice, to swing

the pioneer parties to the east, crossing the Meuse and thus to follow the proposed First Army offensive on the flanking movement toward Metz.

It was during the rapid advance immediately after the 2d of November, when the German resistance in this sector was broken, that Lieut. Joseph A. Tinsman, the Sanitary Corps officer attached to this Company, was fatally wounded. Lieut. Tinsman had started from Verpel with a "chloro-pump," with the avowed intention of advancing till he could catch up with the infantry and supply them with water. He was caught in a traffic jam between Harricourt and Sommauthe, a German battery "opened up" on the road, and during the course of the shelling Lieut. Tinsman received a wound which ultimately caused his death. Tireless, energetic, wrapped up in his work, a good soldier and a competent officer, Lieut. Tinsman met a soldier's death in the performance of his duty, leaving a revered memory with all who knew him.

To Sergt. Hart and party, working on a steel tank and tower at Cheppy, belongs the distinction of being the first outfit of the 26th Engineers to pose for the "movies." On about the 15th of October they were filmed by the Signal Corps.

On November 11 two pioneer parties were located at Raucourt and one at Angécourt, the main body of the Company being in Buzancy. The air had been full of rumors for a week concerning the abdication of the Kaiser, the assassination of the Kaiser, the capture of Sedan, the capture of Metz, armistice terms, and what not. When the heavy cannonading of November 11 suddenly ceased at 11 A.M., the Company was loath to believe that the end had really come until authentic news came forward that the Armistice was actually in effect. The general attitude of practically all soldiers was expressed by the oft-repeated words, "Thank God, it's all over!"

On November 15, owing to the small demand, the former troop concentration no longer existing, the operation of practically all water points in the Argonne district was discontinued and the operators at these points recalled. On this same date Company E relieved Company C in the operation of 14 water points in the Dieue District south of Verdun.

Active operations on the Argonne front having ceased after

November 11, the Third Army was formed to advance as the Army of Occupation. The main artery of supplies for the Third Army, during its march and after the occupation of German territory, was the railroad running north from Conflans through Longuyon and Luxemburg, and thence along the Moselle River to Coblenz. At Verdun there was a connection with the main line running south to the main supply depots. The line between Verdun and Conflans, however, passed through what had been No Man's Land in one of the fiercest conflicts of the war, and required complete reconstruction from Verdun to Etain. On November 17 the Company was transferred to Faubourg Pavé, an eastern suburb of Verdun, and went to work installing locomotive-filling points between Verdun and Conflans. By strenuous efforts the water supply kept up with the track laying, and finally anticipated it. In all, eight points were installed, as follows: Verdun, both ends of the Tavannes Tunnel, Eix, Etain, Darmont, and Conflans. All of these, except the Conflans plant, were operated by the Company until about the middle of December. Then they were taken over by United States railway troops. Repairs were also made to the cast-iron pipe system in the Conflans railroad yard, and the entire French water system put in operation. This work was of great importance, since as many as 23 trains, of 30 cars each, passed over this Verdun-Conflans line in one day, with supplies for the Third Army.

About December 1 salvage operations were started on all points not in operation in the district south of a line from Varennes to Cumieres. All material salvaged was hauled to the Army Engineer Park at Dombasle.

On November 21 a detail of 40 men under Lieut. Fletcher was sent with two companies of the 37th Engineers to investigate and repair the railroad water points between Conflans, Longuyon, and Coblenz on the Rhine. This detail was a part of the first two hundred Americans to arrive in Coblenz. The party returned to the Company on December 22.

On December 22 the operators in the Dieue District were recalled. The Company had resumed military training shortly after arriving at Faubourg Pavé, and this was continued until December 30, when the Company entrained at Verdun for Bor-

deaux, arriving at Bourg-sur-Gironde, near Bordeaux, on January 2, 1918.

Company E was assisted in its work from September 27, 1918, until December 8, 1918, by Company I of the 59th Pioneer Infantry.

COMPANY F.

Company F began its existence as an organization at Camp Dix, N. J., on Friday, April 19, when Capt. Dwight Horton, 1st Lieut. Fred J. Stewart, and Sergt. John J. Pederson were assigned to the Company. On April 20, 2d Lieut. Clarence E. Ericsson was assigned. No further increase was made until April 24, when 15 enlisted men were added. On April 29, 1st Lieut. Lionel M. Levine was assigned for duty, and the same day the Company mess, in charge of Sergt. Stilling, was opened. May 6, 1st Lieut. Garland L. Rounds was assigned to the Company, which by that time had increased in strength to 5 officers and 95 enlisted men.

The usual daily drills were commenced as soon as the first recruits were assigned to the Company, a school for non-commissioned officers was later opened under Lieut. Rounds, and before long the Company began to assume a military atmosphere. A spirit of interest was manifested by the personnel, and success was not only registered in the drills but also in other lines. On May 30 the representatives of the Company won the cup in the 78th Division track meet at Camp Dix, N. J., and on July 4 the Company took part in the divisional review. The company spirit was well illustrated by the singing class, conducted by Sergts. Fulton and Nelson. One hour each day was devoted to this work, and every man in the Company participated. A concert was given by the entire Company at the Y. M. C. A. auditorium, and again camp honors were carried away by "Singing Company F." While participating in these amusements the Company began intensive training for overseas duty, and the same enthusiasm was evident in the work. Several days were spent on the rifle range, gas drills were introduced, and practice marches made. On July 18 the "hour gas hike" was taken, and the following day the Company was passed through the gas chamber. On August 8, 2d Lieut. William H. Withington was assigned to the Company, and two days later 1st Lieut. Albert H. Jewell, of the Sanitary Corps, was attached.

After weeks of anxious waiting, on Saturday morning, August 17, at 6.15, the Company, together with Company E, left the regimental area for duty overseas. The total strength at this time was 7 officers and 246 enlisted men. There were also attached to Company F 10 enlisted men and 1 officer of the Regimental Medical Detachment. The Medical Officer and half of the enlisted personnel were assigned to duty with Company E, but for purposes of simplicity in the paper work incident to transportation overseas, the entire detail was attached to Company F. At 7.15 A.M., the Company left Camp Dix station, arriving in Jersey City at 10.30 A.M. It remained on the pier at the Jersey City station until 2.30 P.M. before being taken by the ferry to Pier 20, Brooklyn, N. Y., the port of embarkation. At 4 P.M. the Company was ordered aboard the steamer *Italia*, and at 6 P.M. the *Italia* steamed out into the harbor, where it anchored for the night.

At noon, Sunday, August 18, accompanied by several other transports and a convoy of cruisers, destroyers, and aëroplanes, the voyage to France began. The entire voyage was without incident. Ideal weather prevailed, and the monotony of the trip was broken only by the various submarine and troop guards, daily boat drills, semaphore practice, physical exercises, physical inspections, and cold salt-water baths. The food provided on board the ship for the enlisted men was a great disappointment to them. The quantity and variety were ample, but the preparation by " steam cookers " was so different from what had obtained in the training camp that many of the men ate very little that was produced in the ship's galley, and lived principally on what they purchased from the ship's sales commissary.

On Friday, August 30, the *Italia* steamed up St. George's Channel toward Liverpool. A little before dusk the hills of Ireland and Wales came into sight. The skipper of the ship pointed out the location of the home of England's Premier, fondly calling him " Lloydie " George. Dusk gradually changed into blackest night, but the intermittent flashes from lighthouses along the coast were a welcome change from the constant blackness of the previous nights of the voyage. Daylight of Saturday, August 31, found the *Italia* gradually working her way to the docks. The landscape spread out to view in the morning light created a deep im-

pression on the troops, who were seeing foreign soil for the first time. The town, on the water's edge, with its closely set houses and thousands of chimneys, the tiny outlying fields, apparently manicured that very morning, surrounded by beautifully kept hedges or carefully laid stone walls, gave truth to the pictures and illustrations of old English novels and fairy tales.

At 9 A.M., the Company disembarked from the steamer at the Custom House Pier, Liverpool, England, and marched through the streets of the city to the Great Central Railway Station. The line of march was thronged with people who had gathered to welcome the "Yanks." With bands playing and the flags of the Allies waving on all sides, Company F was escorted to the station, where at 10 A.M. it entrained for the trip across England This trip proved of considerable interest, and the scenery was admired by every one. At 7 P.M. the Company arrived at Southampton, where it remained in a rest camp until the following day. At 6 P.M. the Company again embarked, and under the cover of darkness crossed the English Channel, arriving at Le Havre, France, at 3 A.M. It was not until eight o'clock, however, that orders were given to disembark.

A French band played popular American airs as the men marched down the gangplank, but the absence of cheering civilians was very noticeable. The long years of suffering were written on the faces of the people who came out of their houses or stores to watch the Americans march through the streets, and their welcome, which consisted mostly of a simple handshake with a word of cheer, was very sincere.

From Le Havre the Company marched 5 kilometers to a rest camp, and spent the next few days in washing clothes and resting after their long voyage. September 4, at 10 P.M., orders were given to entrain. The men were loaded into French freight cars labeled for 40 men or 8 horses, but which actually were designed for only 20 men, and moved to the front. After a three days' journey the Company reached Sorcy-sur-Meuse, the American railhead for the St. Mihiel sector, and detrained at 7.30 P.M. Since there were barracks for but half of the men, it was necessary for two platoons to pitch "pup" tents. This work was done in the rain, and without the aid of lights, the latter being pro-

hibited on account of air raids. The Company remained at Sorcy until Thursday, September 12, during which time details consisting of practically the entire Company, under Lieuts. Levine, Ericsson, and Withington, were placed on duty with the 21st Engineers, on light railway repair and construction work.

On the night of September 12, the opening day of the famous St. Mihiel offensive, a detachment of 70 men under Lieut. Stewart was ordered to proceed to Bernécourt, a village just behind the trenches that had been vacated that morning by the advancing American troops. The trip from Sorcy was made in three motor trucks which were obtained from the 21st Engineers. The party was joined at Bernécourt by Lieut. Rounds and a French wagon train of 12 two-wheel carts with water-supply equipment for Company F. As it was impossible to make further progress during the night, the men were billeted in the ruins of the town, where they slept until daybreak. The surroundings during the first night at the front were not particularly conducive to sleep. The weird aspect of the ruined buildings was enhanced by the reflections from the flare rockets being used by the advancing "doughboys," and from the anti-aircraft searchlight rays in their constant hunt for the Boche planes high overhead. Occasionally a plane would drop a few bombs, probably intended for the demolition of an American ammunition dump, and above everything else was the thundering of cannon mixed with the rattle of small arms.

The heavy barrage of the morning had not greatly impressed any of the party, as every one had formed some idea of what to expect. All knew, from the preparations being made, that there was to be a drive, and certain culminating events which occurred on the night of September 11 led every one to expect the drive to start the following morning. Everything that occurred was taken as a matter of course by the men of Company F, principally because they had no time to think about what was taking place around them. Only twenty-five days had elapsed from the time they had last looked upon the shores of America. They were now at the front in France, being called upon to do their bit with America's First Army in its first drive against a foe which had all but defeated the combined armies of the principal allies. The duty assigned to the Company in this offensive was to supply water to

the troops and animals of the divisions attached to the IV American Corps. The members of the Company did not know what kind of tools or equipment would be available for the work. Neither did they know what kind of construction would be applicable to the available sources of water supply. They merely knew that they were on hand with a willingness to do their best and make the most of whatever was available.

On the morning of the 13th two working parties were organized to follow the advancing infantry, Lieut. Stewart being in command of one and Lieut. Rounds the other. The first thing that forced itself on the two officers was that they had to furnish breakfast to the hungry personnel. There was food, but the Regimental Supply Department had overlooked furnishing stoves of any description. It was then that Company F did its first salvaging, and at the same time learned that it was now necessary to look after itself and not depend on others. Some organization had inadvertently unloaded a field range behind a dilapidated building and for the moment had left it unguarded. In the wink of an eye, the range was the property of Lieut. Stewart's detail, and within ten minutes Cooks Julius Devogel and Charles Baker had a breakfast of " stew " and coffee well started. This field range remained with the Company until late in December, when the Company was ordered to rid itself of all equipment and proceed to the embarkation camp at Bordeaux. It was many times repaired by Private J. G. Simonson, the Company's sheet-metal worker. During the preparation of breakfast, Lieut. Rounds's detail was successful in salvaging another field range, which remained the property of the Company until the order was received to go into Germany with the Army of Occupation.

A few hours after Lieuts. Rounds and Stewart had marched forward with their detachments, the remainder of the Company arrived at Bernécourt in trucks, and two other parties were immediately sent out under Lieuts. Levine and Ericsson. Each party was accompanied by three of the French carts which transported their equipment and supplies. Company Headquarters remained at Bernécourt until the following day, September 14, when it was moved to Pannes, a village centrally located in the recaptured territory of the St. Mihiel salient.

The work of the advance parties was pioneer in character. Canvas reservoirs for drinking water were installed at various important points along the main roads and as close to the line of resistance as concealment for the water carts and tank trucks was obtainable. Water was hauled to these reservoirs by motor tank trucks, which filled at mobile purification trucks placed in

CART AND TANK TRUCK FILLING STATION AND ANIMAL WATER TROUGH ON AVOCOURT-VERY ROAD.

Supplied from 1 350-gal. steel tank on tower filled by gasoline engine-driven pump from a spring. (Argonne Meuse offensive.)

operation along the Rupt de Mad, the only stream in the recaptured area. In addition to installing these canvas tanks, hand pumps were repaired or installed at water points, wells and *lavoirs* (French wash houses) were cleaned, horse troughs erected, streams paved for use by animals, storage tanks erected, and mobile purification trucks placed.

The area assigned to the Company in this offensive included the section over which the greatest advance was made by the infantry. The various detachments covered this area very thoroughly, and every available source of water supply was developed. The four working parties maintained contact with themselves and with adjacent water-supply troops. On the right, contact was main-

tained with Company D, 26th Engineers, under Capt. John C. Pritchard, and on the left, with Company D of the 37th Engineers, which for this emergency was acting as a water-supply company. The water-supply troops of the entire area were serving under the advice of the officers of Company B, 26th Engineers, who prior to the drive had developed the water supply in the area up to the lines occupied by the American troops. In addition to establishing water points, a reconnaisance of the recaptured area was made by the Company officers, which furnished valuable information for the Intelligence Department of the Water Service.

An unexpected difficulty in this first experience of occupying former enemy territory was the temptation to hunt souvenirs when there was work to be done. However, after the first day the men realized that the work should be done first and souvenir hunting later. Some of the men gathered enormous quantities of relics which they later discarded when they saw that they could obtain such things any time they chose, and that the extra weight during a march under heavy packs did not help them along the shell-torn roads. During the five or six days spent by the Company in this area, no food of any kind could be provided the details by the Company organization, and it was necessary to beg, borrow, and steal from other organizations. Thanks for assistance is due a supply company from the 1st Division. It is believed that this organization was the 26th Supply Company. Its generosity kept at least one of the details, Lieut. Stewart's, from being very uncomfortable from hunger.

During the offensive the entire Company was under continual shell fire, but only two casualties resulted. Sergt. Barton and Corp. DeVault were injured by shell fragments at Pannes, on the night of September 16, and were sent to the hospital for treatment. The shell which injured the men also killed two of the Company mules. This incident is worthy of mention in that it shows to what extent the good fortune of the Company obtained during its participation in events at the front. The two men above mentioned, together with the driver of the mules, were sitting or lying under an escort wagon to which the two mules were tied. The shell fell in the midst of the men, and the explosion tore the mules and wagon into small bits and scattered them over a

large area. The two men were injured and the driver was not even touched. After the explosion, the corner of the blanket on which the driver was lying was hanging in the shell hole. This incident is typical of many which occurred during the offensives.

On September 17, the advance in the St. Mihiel sector having practically ceased, Capt. Horton and Lieut. Rounds were ordered to proceed immediately to Auzéville on the Argonne-Meuse front, and Lieut. F. J. Stewart was left in command of the Company. Lieut. Withington was the only officer at Company Headquarters when Capt. Horton and Lieut. Rounds were taken away, and his information consisted of instructions to assemble the Company and await probable orders to move somewhere. This bit of information was supplemented by a map showing the location of Auzéville. September 18 the Company was reassembled at Pannes, and at 6 P.M. moved to St. Baussant, where it remained until the following night.

The day of September 19 was spent in cleaning out some German shell-proof troop quarters in which it was planned to shelter the men until orders were received to move.

A German water-supply material dump in St. Baussant was straightened up, and material and usable equipment cleaned and placed where it would be protected from loss and disorder. The grounds about the quarters and dump were cleaned of their filth, drainage ditches were dug, and by 3.30 P.M. the place was in a very livable condition, and was perhaps the best housing the Company had up to the time headquarters was established at Nouart, in November.

On September 19, about 5.30 P.M., orders were received to proceed to Auzéville. At 10 P.M., after turning over all engineer equipment to Company B, 26th Engineers, at St. Baussant, the march began. The march orders required that the movement be made under cover of darkness. The Company was accompanied by a 5-ton truck which carried the kitchen and supplies. With but one truck to haul the food, tools, kitchen equipment, baggage, cooks, and men who had become lame and sick, it was necessary to load to the limit of space, and consequently the weight was probably twice the capacity of the truck. Hence it is not to be wondered at that the truck continually became stuck

in shell holes along the road. It was unloaded and loaded several times during the first leg of the journey, and did not arrive at the first camping place until about three hours after the Company had gone to sleep. Rain fell continuously during the night, and the roads, damaged by enemy shell fire, were nearly impassable. The men were carrying packs with full equipment, and had considerably more weight than is normally carried by foot troops on a long march. The longer it rained the more weight the men had to carry, and the footing became more and more difficult. Added to this the men were tired, to start with, having worked hard during the day to get their quarters and grounds in a livable condition. Corp. LoBello, the smallest but not the least mighty man in the Company, excited considerable comment from passing troops due to the size of his pack compared with his own size. One "doughboy" was curious to know why he wanted to be "packing" a dead man around with him. A stop was made in the village of Mont Sec, and water for filling canteens was obtained. Mont Sec was probably one of the strongest fortifications which the Germans possessed, but the American troops had taken it so quickly that the Huns did not know what had happened. Progress was slow and difficult, and at 3.30 A.M. of the 20th, after climbing a long, steep hill, camp was made in the big forest between Woinville and St. Mihiel. Some of the men pitched "pup" tents and others found German dugouts. Lieut. Levine rolled himself up in a shelter-half, lay down in a ditch beside the road, and was asleep immediately. In the darkness and rain he was several times mistaken for a log.

After breakfast had been prepared and eaten, all went to bed again and slept the balance of the day. The rain ceased at daylight, and by evening all felt more cheerful although very stiff and tired. At 8.45 P.M. the march was continued under command of Lieut. Levine, and at 11 P.M. the Company arrived at the entrance to the town of St. Mihiel, where it was necessary to repair a mined road before the truck could proceed. While engaged in this work, air raids, which had begun over the town at nine o'clock, were continued, and, no other cover being available, it was necessary to deploy the Company and take advantage of the shelter offered by the drainage ditches on either side of the road. The raids

continued at short intervals until 2 A.M., when a runner arrived from Lieut. Stewart, who had preceded the Company into the town, with orders to fall back to the woods one kilometer from the town and camp for the remainder of the night. The next morning, in order to continue the march without attracting undue attention, the Company was split into small detachments, and, taking advantage of cover, marched to Rupt, where it was reassembled at 3 P.M. At 11.30 P.M., the Company was picked up by motor trucks which were brought by Lieut. Stewart who had gone on to Auzéville during the day for the purpose of getting more transportation. Auzéville was reached next morning, and headquarters was established and the men billeted.

On September 22 Capt. Dwight Horton, due to the manner in which his work had been planned and executed during the St. Mihiel offensive, was appointed Sector Water Supply Officer of the Northern Sector, First Army. This sector included the whole of the Argonne-Meuse front. Lieut. G. L. Rounds was appointed engineer supply officer for the water-supply companies operating in the Northern Sector, and 1st Lieut. Fred J. Stewart was made acting commanding officer of Company F.

Preparations were immediately commenced for the work to be done by the Company in the expected offensive. Water-supply equipment was concentrated. Six Mack cargo trucks, mobile purification trucks, blacksmith shop, and laboratory were assigned to the Company, and also an assortment of small power pumps, pipe, tanks, pipe fittings, horse troughs, and engineer tools. A permanent water-filling station was erected at Vraincourt by a working party from the Company under Lieut. Levine and Lieut. Ericsson, and repairs were made on four canvas reservoirs in the Bois de Hesse by a party under Lieut. Withington.

With the beginning of the Argonne-Meuse offensive on September 26, 4 advance parties of 20 men each were sent out to follow the infantry and artillery of divisions attached to the V Corps and do the customary pioneer water-supply work. These parties were in charge of Lieut. Levine, Lieut. Ericsson, Sergt. Stevenson, and Sergt. Fulton. Each party was accompanied by an escort wagon which transported the rations and engineering equipment. These advance parties proceeded by forced marches

to areas immediately behind the line of resistance, and there developed the water resources at hand. September 27, Lieut. Withington was sent out with a party of 20 men to install semi-permanent cart- and truck-filling points. The first installation was made at Avocourt, where there was an important road junction. After the first stage of the offensive was completed, the pioneer parties also began work on semi-permanent water points.

ANIMAL WATERING POINT AT CIERGES ON SMALL STREAM.
Stone-paved approach to right of bridge. Fence enclosing the pool.

During the first few days of the offensive of September 26, it was again impossible to get rations to the pioneer parties, due to the impassable condition of roads across the old No Man's Land. Hundreds of ration and supply trucks were mixed in the traffic jams at the edge of No Man's Land, and could not move until the road engineers had built temporary roads, which they did by working day and night. In places where fighting had been going on for four years, the roads between the two lines of resistance were entirely obliterated, and in their places were areas of great shell holes. Thus it was again necessary to resort to begging from those who had a few extra rations. Two of the details were fortunate in salvaging a small quantity of provisions from abandoned

German kitchens. Sergt. Stevenson's detail at Montfaucon succeeded in obtaining enough German flour to last for about two weeks.

The work of the parties installing semi-permanent water points consisted primarily in the erection of a small power pump at an available source of supply, usually a spring, and connecting it by a 2-in. or 4-in. pipe line to a 1 300-gal. steel tank elevated on a wooden tower. The water was delivered from the tank to standpipes erected at the sides of roads, accessible to water carts or motor tank trucks. In many cases it was necessary to build a special road turnout, so as to prevent congestion of traffic on the principal highways. The semi-permanent plants often displaced mobile purification trucks, which could be moved forward with the advancing combatant troops and put into operation in thirty minutes after arrival at the source of supply. Lieut. A. H. Jewell was in charge of these trucks and also of the sanitary reconnaissance of the Company sector.

Company Headquarters and Headquarters of the Water Supply Officer, Northern Sector, were moved to Recicourt on September 28, in order to be nearer the advancing pioneer parties and the water-supply dump at Dombasle. During the sojourn at Recicourt, Major Fricke, the regimental surgeon, established an infirmary and succeeded in having a dentist, Lieut. Cowan, assigned to duty. The services given by both were appreciated very much both by the men of the regiment and by casual officers and men in need of attention.

On October 4, Company K, 59th Pioneer Infantry, Capt. Davis commanding, was attached to Company F for duty. The men of the Pioneer Infantry were used as labor troops and as guards at the various water points that had been constructed by Company F. The large number of men who were required to guard and operate the ever-increasing number of water points had gradually reduced the available strength of Company F to a number which would not permit of full working crews on construction. The Pioneer Infantry relieved this difficulty, and the willingness of its men to do hard work brought many favorable comments from detachment commanders. Capt. Davis, although reporting to an officer his junior in rank, realized that all were working for the

same cause, and showed a great willingness to do every duty that was asked of him. The Pioneer Infantry remained with Company F until the latter commenced its journey to the Rhine.

From October 5 to 30, while waiting for a renewal of the offensive, all of the working parties were engaged on semi-permanent installations. On October 25, Company Headquarters were moved from Recicourt to a point one kilometer south of Cierges. Capt. Horton still maintained the Northern Sector Headquarters with Company F, as the latter continued to operate in the center of the sector. This simplified the matter of transportation and communication with the two companies on the flanks. It was also rumored that the officers attached to Northern Sector Headquarters did not object to the quality of the meals which were served from the Company F kitchen by Mess Sergt. Stilling and his cooks. Major Fricke continued to operate his infirmary, and was often called on to give aid to wounded and sick. The Company Headquarters at Cierges was situated between the latter village and the town of Montfaucon, on the reverse slope of a rather high hill, so that it was rather inconspicuous. For the greater part of the time there were many troops and batteries in the vicinity, but none close enough to draw attention to the spot occupied by Company F. Consequently the officers and men about headquarters were enabled to view with comparative safety the result of shell fire put over by the Germans in search of batteries and troop camps which occupied almost every woods and clump of brush in the area. Air fights during the day and bombing "parties" at night were continually taking place. Each day a few shrapnel or high explosive shells would fall close to Company Headquarters, but the greater part of the day held no such unpleasantness. The field parties were assisted in their operations by the untiring efforts of Truck Sergt. Quintette and drivers F. E. Thompson, Pelham, Warner, Bendelow, D. C. Smith, C. C. Cooper, and Bosworth, who often drove day and night over the artillery-swept roads in order to deliver supplies and equipment to the working parties. The assistants of these drivers are also deserving of a great deal of credit for their faithful work.

Lieut. Fletcher reported to the Company on October 29, and acted as liaison officer between the division engineers in the V

Corps area and the commanding officer of the Company. He was also engaged in reconnaissance work within the Company sector, and gathered much valuable information relative to the water supply close to the ever-advancing front. He remained with the Company until November 7, when he was called away by Regimental Headquarters to construct watering stations for locomotives on narrow and standard gage railroads operated by the First Army.

On November 1 the Argonne-Meuse drive was renewed. Sergt. Koyle replaced Sergt. Stevenson, and the four former advance parties, doing pioneer water-supply work, followed the advance of the combatant troops who went " over the top " on that morning. These advance parties attempted to develop the water sources behind the advancing troops, but the advance was so rapid that the parties were forced to leave a wide expanse of territory undeveloped and proceed by marches to the areas immediately behind the line held by the infantry and there establish the water points. Wells and springs were cleaned, and curbing built around them. Hand pumps were installed at points accessible for water carts. Mobile purification trucks were placed near the front. Roadways at and around cart-filling stations were built and repaired. Old civilian wash houses were cleaned out, many being in a very filthy condition. Hand pumps were installed at wash houses where conditions warranted. On November 2, reserve parties, under Lieut. Withington, Sergt. Stevenson, and Sergt. Rogers, were placed in the field, doing work of a character similar to that done by the advance parties at places which of necessity had been left unserved during the hurried advance. These reserve parties installed power pumps, and in some cases hand pumps, at mobile purification truck locations, so that the trucks could be released for use farther ahead or at other points where needed.

Pvt. Schellhammer was wounded by a shell at Banthéville, November 1, while waiting with a side car for Lieut.-Col. Scheidenhelm, Regimental Commander, who had gone forward afoot.

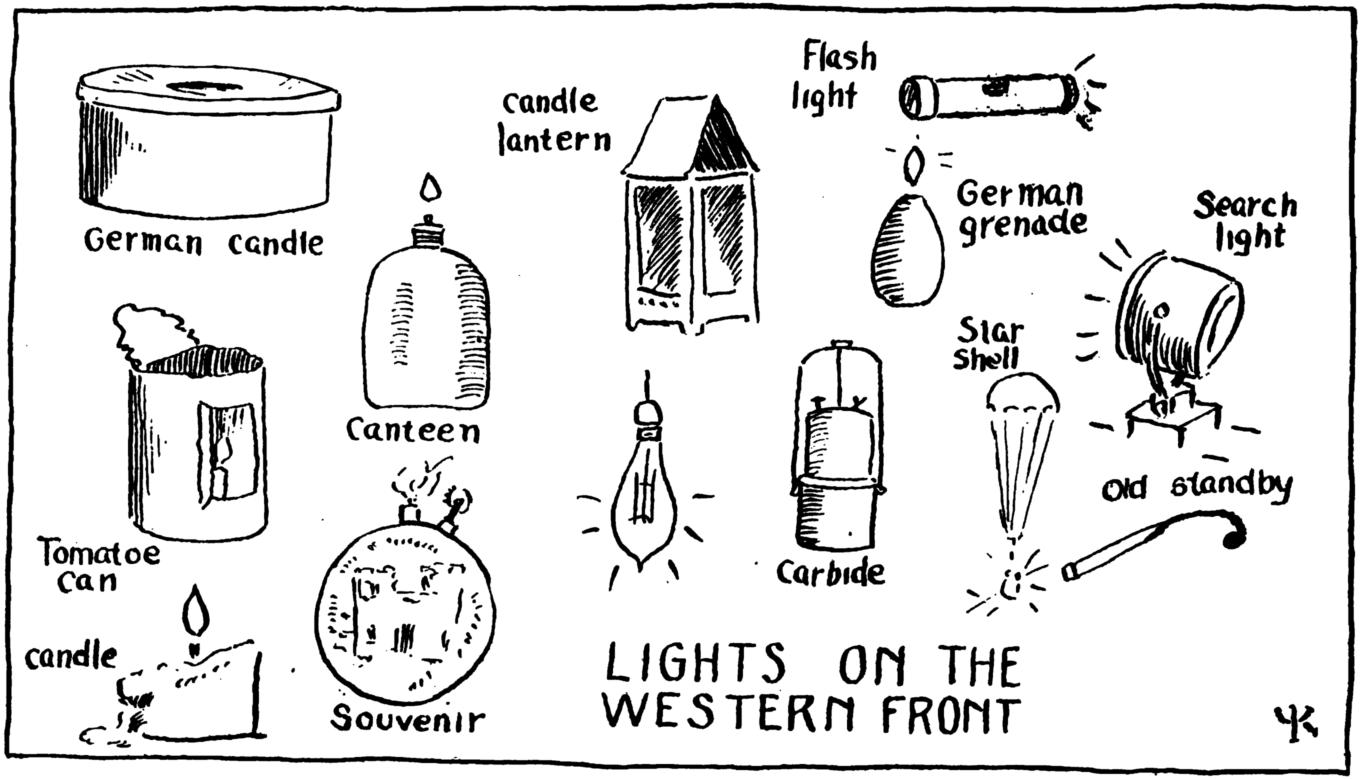
On November 5 the Company Headquarters was moved to Nouart, Department of Meuse, and located in the " Haus Marianne." This was a large French farmhouse situated on the Buzancy-Nouart-Stenay highway on the east edge of the village of

Nouart. The house had evidently been taken over by the Germans in their first advance into France in 1914, and had been occupied by them ever since. How they came to name the building "Haus Marianne" is not known. House naming seemed to have been a fad in this village, however, for almost all the better houses had a name painted in large letters across the front. At Nouart, Company F had the most comfortable quarters during the whole of its sojourn in Europe, and it was with a great deal of regret that they were abandoned when orders were received to proceed into Germany. At Nouart orders were received relieving Capt. Horton from further duty with the Company and appointing Lieut. Stewart as commanding officer. The latter had acted as Company commander since September 19 and had successfully led the Company during the Argonne-Meuse offensive. Second Lieut. Joseph I. Murray, Sanitary Corps, was attached to the Company at this time. Lieut. Cowan, Dental Corps, was sent to Buzancy with Company E, 26th Engineers. On November 13 three of the advance parties were moved to the east bank of the Meuse and began the investigation of the water-supply system of the city of Stenay, together with the repair of a bath and laundry and delousing plant south of Stenay on the Verdun road.

November 15 orders were received to mobilize the Company at Liny-devant-Dun and prepare to join the advance into Germany. The assembling of the Company was completed at 5.30 P.M. on November 16. Second Lieut. James F. Blake was attached to the Company at Liny-devant-Dun and also Second Lieut. Trowbridge with 37 men from the 301st Water Tank Train and 1st Lieut. R. V. Donnelly. Lieut. Rounds returned to the Company from Northern Sector Headquarters. A great deal of difficulty was experienced in assembling the men on such short notice, due to the fact that it was necessary to pick them all up during the night of the 15th. Those of the men who were not at Company Headquarters or with one of the advance working details were on guard or working as operators at the various water points which had been installed by Company F. At night there was very little call for water after eleven o'clock, and consequently the men were asleep in dugouts, old buildings, and in various out-of-the-way places in the woods, which made it exceedingly difficult

to find them. However, by working all night, Lieuts. Withington and Jewell finally collected all the men except three and brought them to headquarters on trucks. It had also been necessary to notify all the men of the 59th Pioneer Infantry to return immediately to their own company. The three men not collected that night were Putman, Turner, and Edward Thompson. The two former were on duty with the Quartermaster Corps, doing pipe fitting at a large gasoline station in Clermont-en-Argonne. Thompson was operating a pumping plant at Banthéville and could not be found, as he had gone to bed, it being nearly morning when the trucks arrived at his station. He remained on duty until all the American troops had moved away from his area, and when he could not get anything more to eat, he walked into Dun-sur-Meuse for rations and there found that the Company had gone into Germany. The three men, together with Sergt. Crank, who had remained with Capt. Horton as chauffeur, joined the Company at Mullenbach, Germany, being brought there by Regimental Chaplain Sterrett and Lieut. Sellnow of Company E.

November 17, at 1.17 A.M., orders were received to equip the Company with clothes and divide the Company, tools, equipment, and rations into two equal parts, — one part to report to the 32d Division at Marville and one part to 2d Division at Stenay, by 6 P.M. on November 17. The Company commander was to alternate between the two divisions for one week at a time, and to spend the first week with the 32d Division. The detachment with the 32d Division was placed in charge of Lieut. Rounds and the one with the 2d Division in charge of Lieut. Levine. The total strength of the Company at the beginning of the movement with the Army of Occupation was 280 men and 10 officers. There were six 5½-ton Mack cargo trucks, one 2½-ton trailer, ten ¾-ton White water-tank trucks, three motorcycle side-cars, one sterilab, two chloropumps, and one mobile laboratory, making a total of twenty-six motor-driven vehicles and one trailer. There were four complete sets of pipe-fitting tools, an assortment of pipe and pipe fittings, four complete sets of 75-ft. horse-watering troughs, several tarpaulins to be used as linings for storage reservoirs, four small power pumping units, six hand pumps with hose connections, an assortment of earth-working tools, four complete sets of


German candle
Tomatoe can
candle
Canteen
Souvenir
candle lantern
Flash light
German grenade
Carbide
Star Shell
Search light
Old standby
LIGHTS ON THE WESTERN FRONT
YK

carpenters' tools and five days' rations. It was somewhat of a "hurry-up" job to divide the men and equipment into two parts, distribute new clothes, and complete the movement on time. However, by hard work, the task was accomplished, and at 4.30 in the afternoon the two detachments reported to their respective divisions, one and one-half hours ahead of schedule. A plan of action was mapped out by which the detachments would follow the advance section or reconnaissance engineers and do reconnaissance work in water supply. This work consisted of posting signs showing where potable water could be obtained and indicating which sources of supply should not be used for drinking. Sources of supply were cleaned up and repaired and bacteriological tests were made of many sources of supply.

The move into Germany was attended with a great deal of pleasure, although there was a certain amount of hardship. The work itself was not difficult, and new and interesting country was being seen daily. However, the weather was chilly, and for the most part the men were billeted in buildings without heat of any kind. Food was scarce with the detachment accompanying the 32d Division, due to the fact that insufficient trucks were available to make the long haul from the railhead. Two meals a day, consisting of black coffee, hard tack, and canned corned beef ("canned Willie") were often the order. The detachment with the 2d Division fared better in so far as rations were concerned.

A few prisoners were taken by a detail under Lieut. Withington. Three German soldiers had failed to clear the territory in specified time, and the detail, doing reconnaissance work with the advance guard, had run on to them. The prisoners were sent back to the military police.

The impressions gained of the German inhabitants by the men and officers of Company F were of a varied character, as was evidenced by the arguments which occurred after the return from Germany. All apparently seemed to think that any pleasant advances made by the inhabitants were merely as propaganda to gain favor with the Americans. The treatment was as fair, probably, as could be expected from a defeated people. Only in the city of Coblenz was there a wholesale evidence of the overbearing character of the Prussian, and it was exceedingly difficult to

refrain from taking offense at the impoliteness of the inhabitants. The inclination of most of the Americans was to settle difficulties right on the spot by means of the " manly art."

Under orders of the Chief Engineer, Third Army, Lieuts. Rounds and Donnelly were, on December 5, sent into Coblenz to make valuations and investigations of public utilities situated along the River Rhine. This work lasted until December 12, when the two officers returned to the Company. The work done by the Company was apparently appreciated, as it was several times mentioned by various officers of the two divisions.

It might be well to add that, due to the great lack of motor tank transportation, it was impossible to get sufficient gasoline to move the two divisions as rapidly as was desired. By an arrangement with the supply officers of the two divisional engineer regiments, a number of the water tank trucks with Company I, 301st Water Tank Train, were put into the gasoline service. The arrangement was very much appreciated, and was frequently spoken of as having made possible the forward movement of the truck transportation of the two divisions.

The line of march of the two detachments and Company Headquarters was maintained as indicated below:

DETACHMENT WITH 32D DIVISION.

November 18 — Marville, France.
19 — Marvillé to Longwy.
20 — Longwy to Neiderkirchen, Luxemburg.
21 — Neiderkirchen to Dommeldange.
22 — Dommeldange to Gonderdange.
23 — Gonderdange to Hemstal.
30 — Hemstal to Rosport.
December 1 — Rosport to Welschbillig, Germany.
2 — Welschbillig to Zemmer.
5 — Zemmer to Himmerod.
6 — Himmerod to Gemunden.
7 — Gemunden to Kelberg.
8 — Kelberg to Kaisersech.
9 — Kaisersech to Mayen.
10 — Mayen to Welling.
11 — Welling to Saffig.
13 — Saffig to Urmitz.
14 — Urmitz to Heimbach.
15 — Heimbach to Oberbieber, crossing Rhine at Engers.
16 — Oberbieber to Neuendorf.

DETACHMENT WITH 2D DIVISION.

November 17 — Liny-devant-Dun to Stenay to Chauveney-le-Château, France.
18 — Chauveney-le-Château to Harnoncourt.
20 — Harnoncourt to Miex-le-Tige, Belgium.
21 — Miex-le-Tige to Hobscheid, Luxemburg.
22 — Hobschied to Reckingen.
23 — Reckingen to Rollingen.
23 to 30 — The Detachment remained at Rollingen.
December 1 — Rollingen to Lahr, Germany.
2 — Lahr to Oberweiler.
3 — Oberweiler to Schönecken.
4 and 5 — The Detachment remained at Schönecken.
6 — Schönecken to Gerolstein.
7 — Gerolstein to Dreis.
8 — Dreis to Aderfarhof.
9 — Aderfarhof to Ahrweiler.
10 — Ahrweiler to Remagen-am-Rhine.
11, 12, and 13 — Detachment remained at Remagen.
14 — Crossed Rhine at Remagen and proceeded to Bendorf.
15 — Remained at Bendorf.
16 — Recrossed Rhine to Neuendorf to assemble.

COMPANY HEADQUARTERS.

November 16 — Liny-devant-Dun, France.
17 — Liny-devant-Dun to Marville.
18 — Marville to Longwy.
20 — Longwy to Petange, Luxemburg.
21 — Petange to Walferdange.
22 — Walferdange to Niederanwen.
23 — Niederanwen to Consdorf.
24 to December 1 — At Consdorf.
December 1 — Consdorf to Welschbillig, Germany.
2 — Welschbillig to Oberweiler.
3 — Oberweiler to Schönecken.
6 — Schönecken to Daun.
7 — Daun to Mullenbach.
9 — Mullenbach to Mayen.
10 — Mayen to Ochtendung.
11 — Ochtendung to Bassenheim.
13 — Bassenheim to Sayn, crossing Rhine at Engers.
16 — Sayn to Neuendorf, where entire Company assembled.

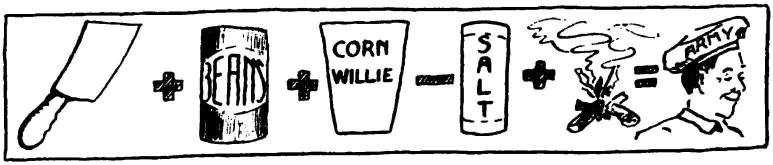
After completing the march to the Rhine with the Third Army, the reconnaissance parties were ordered to leave their respective

divisions and return to Neuendorf, on the Rhine, where the Company was to be assembled. Rumors began to spread rapidly that the four companies of the 26th Engineers which had remained in France were preparing to return to the United States, and that Companies C and F with the Third Army would be ordered to return to the Regiment and embark with them. Enthusiasm was displayed by the entire Company F in the daily drills at Neuendorf, and reached a higher stage when Company C of the 26th Engineers likewise began to assemble in Neuendorf. On December 18 orders were received stating that the work of the water-supply companies with the Third Army was completed and that immediate preparations should be made to return to the regiment in France. In compliance with these orders, the water-supply material and trucks were turned over to the Chief Engineer, Third Army. The following day the companies marched from Neuendorf to Coblenz, where they entrained at 10 A.M. for Sorcy-sur-Meuse, France.

December 20, 6 P.M., the two companies detrained at Sorcy and were billeted in the wooden barracks of the 22d Light Railway Engineers, near the railhead. The following morning, due to the congested condition of the barracks, Company C moved into the town of Sorcy-sur-Meuse, where Companies A and B of the 26th Engineers had assembled, the remainder of the Regiment having remained at Verdun.

From December 20 to December 30 Company F remained at Sorcy. Infantry drills were held each day, and the men were issued new equipment. On December 30 the movement to the base port was ordered, and after waiting three hours in the rain the regimental train, with Headquarters and Companies D and E, arrived from Verdun. At 9 P.M. Companies A, B, C, and F had entrained, and at 11.30 P.M. the train left Sorcy. The next two days were spent on the train. The men were badly crowded in the freight cars, but, contrary to the usual custom of the French railroads, an excellent schedule was maintained, and the Regiment arrived at Bourg (30 kilometers from Bordeaux) at 6 A.M., January 2, where it detrained. The billeting accommodations in Bourg being very limited, Company F was marched to Pregnac-et-Gazelles (Plumet), 6 kilometers from Bourg, where billets had been secured by Lieut. Levine.

At Pregnac-et-Gazelles a schedule was adopted similar to the one used in Sorcy. Infantry drills were held daily, and preparations were made for the movement overseas. Although considerable impatience was displayed in the anxiety to start home, a great deal of pleasure was derived from the stay at Pregnac, and many pleasant memories of the quaint little village will ever remain with the Company.



CAMOUFLAGED CANVAS TANK.
A forward Water Point during Argonne-Meuse offensive.

Enlisted Personnel of Regimental and 1st Battalion Headquarters, 26th Engineers, Bourg-sur-Gironde, France, January, 1919.

REGIMENTAL HEADQUARTERS.

The 26th Engineers was organized in accordance with General Order 108, War Department, 1917, which, among other things, authorized a Regimental Headquarters consisting of 6 officers and 38 enlisted men. Major E. H. Whitlock acted as first commanding officer of the new Regiment, beginning September 10, 1917, but was soon succeeded by Col. E. J. Dent, Engineers. As the other officers who had been assigned to the Regiment reported for duty, Capt. Robert Boettger was designated adjutant and Capt. W. M. Shallcross, supply officer.

Enlisted men were first assigned on November 15, having been selected in part from the personnel of the several companies, but mostly from men who were already on duty at Regimental Headquarters. During the remainder of their stay in the United States they were very busy receiving recruits who were coming in every day, clothing and equipping them, and otherwise taking care of them in their first steps in the army.

In January, 1918, three men of Regimental Headquarters were selected as officer material and sent to the Third Officers' Training Camp at Camp Dix, N. J. These men were: Sergt. G. A. Ketchum, Private C. B. Dewees, and Private V. C. Compton. After graduation they were sent to a camp in the southern part of the United States and received commissions as second lieutenants.

The following March, Company C was instructed to prepare for overseas service. At the same time, orders were received to send a part of the enlisted personnel of Regimental Headquarters to France, where they were very badly needed. As a result of these orders, the following men, all of Regimental Headquarters, accompanied Company C to France during the latter part of March, 1918: Master Engineer Chas. E. Duvall, Master Engineer William H. Worden, Master Engineer F. B. Barns, Master Engineer Geo. W. Duncan, Sergt. Jos. G. Kraft, Private E. R. Hoffman, Private A. T. Kuys, Private R. T. Lacey.

Despite this loss of part of its personnel, the affairs of Regimental

Headquarters continued to move along very smoothly, the only bad reports being the number of bottles collected in its area by the O.D. About the middle of April a 26th Engineers band (volunteer) was organized, and was quartered and messed with Regimental Headquarters. The resulting difficulties were as few as could be expected, and the nightly band practice aided in establishing a mutual friendship. Finally, scores were evened by giving the band a cold shower bath.

About the middle of May, 1918, word was received for Regimental Headquarters and Company D to prepare for immediate overseas service. On May 22 they were duly inspected and reported ready, but orders to move to the port of embarkation were not received until about June 18. They left Camp Dix by train about 1 A.M. of the 22d of June and proceeded to Jersey City, thence via ferry boat to the army docks at Hoboken. Before noon they had embarked on the U. S. transport *President Grant* (formerly a German ship). The vessel left the dock about 4 P.M. and steamed down the harbor for the night with all troops below deck. The following morning, alas! the 26th Engineers contingent was compelled to watch the departure of the remainder of the convoy, for the refrigerating plant of the *President Grant* had broken down.

It was necessary to repair the plant at once, for there were 40 carloads of beef on board. On returning to the dock, part of the troops disembarked immediately, but those of the 26th Engineers did not receive orders to disembark until June 25. They then transferred to a ferry boat which took them to Long Island City, where they entrained for Camp Mills, L. I. Arriving there in the late afternoon, they marched two miles to several rows of tents which had been assigned to them. Here they remained until June 29, fighting the dust during the day and the cold at night. Nearly every one got "aëroplane neck," for there were a dozen or more machines in the air all the time from the nearby Mineola Aviation Field. The planes could also be heard at night, since the pilots were practicing night maneuvering.

On the morning of June 29 they left Camp Mills via train and ferry boat for the Hoboken docks, where they again embarked on the *President Grant*. Most of the other troops on board were

colored, some of them being June automatic replacement men drafted from the South. Many had never before been ten miles away from home. In the afternoon the ship dropped down the harbor for the night, this time with every one on deck and the band playing. Then early on the morning of June 30, the passengers watched the Statue of Liberty fade from sight, and were indeed on their way to France.

As senior army officer on board, Col. Dent was in command of the troops, over five thousand in number. This entailed a lot of work, especially for Regimental Headquarters. The band of the colored troops gave daily concerts. One of the favorite sayings of the negro soldiers, whenever anything was dropped, was: "Sergeant, take his name." Time passed quickly, and on the evening of July 12, the harbor of Brest was reached. Preparations were made at once for debarkation, and early on the morning of July 13 the troops were lightered to shore. Prior to leaving the boat, arrangements had been made to provide two days' rations for all troops on board. A detail of "duskies" from the South was selected for this task. It was readily discernible that they had had little military training. However, they did manage to give a good imitation of a "mob scene," and finally became a hopeless black mixture, while trying to execute the commands given them. In desperation, Col. Dent took charge. To his commands they responded with a will (?), and the work was finally finished. Though the Regimental Headquarters personnel thumbed their "I.D.R.'s" industriously, none of them ever found quoted therein the commands given that day by Col. Dent.

With Regimental Headquarters leading the column, the march was begun to Pontanezen Barracks, a distance of about three and one-half miles. This march tried the spirit of every man, as it was a very hard grind, under heavy packs, after being on board ship for two weeks. Because of it, the first experience in France remains an unpleasant memory to most of the men present.

Shortly after reaching Pontanezen Barracks, Regimental Headquarters and Company D parted, the latter leaving for Baccarat, near the Vosges Mountains, on eastern front. Regimental Headquarters, however, remained until July 26, taking life easy. The hardest work was "Pedro" playing. Here the 34th Engineers,

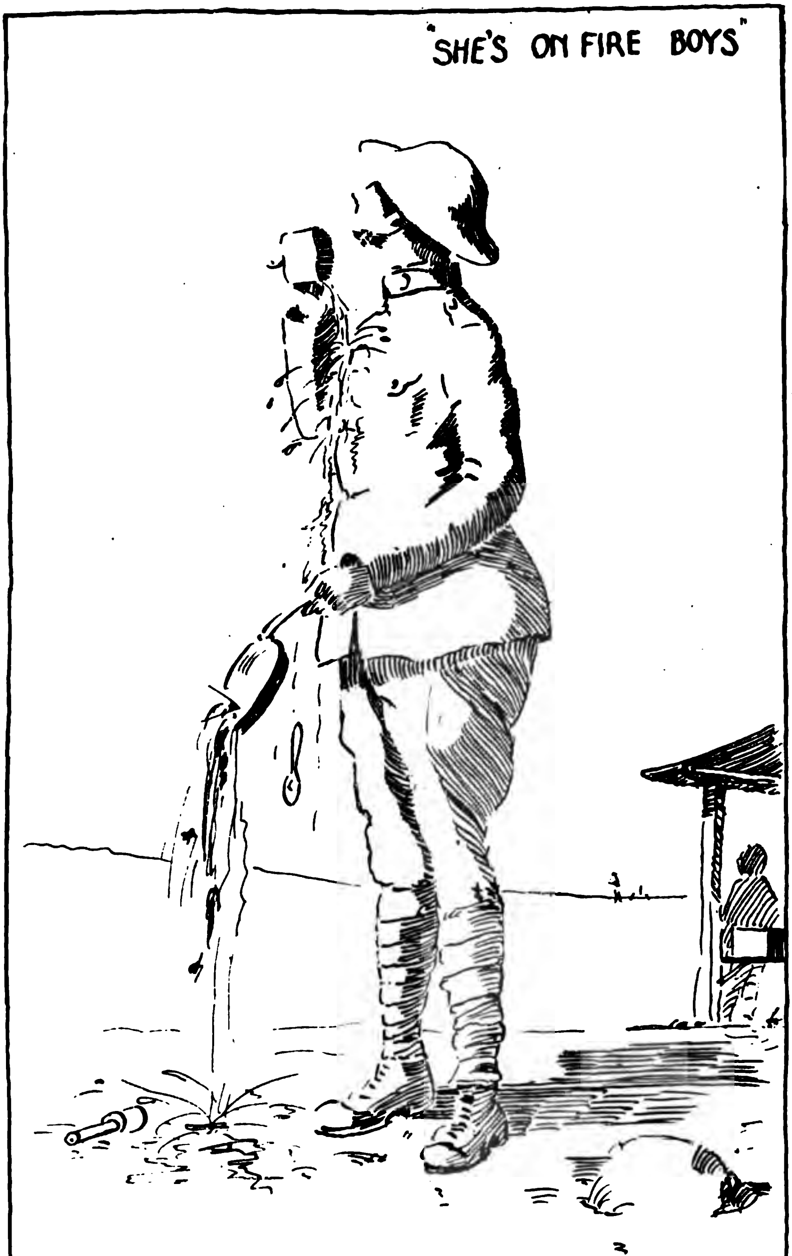
left behind at Camp Dix, caught up with the contingent of the 26th Engineers.

On July 26 Regimental Headquarters marched back to Brest and entrained for Neufchâteau, Headquarters First Army. The trip was made in "40 Hommes — 8 Chevaux" cars. This was the introduction of Regimental Headquarters to "side-door" pullmans, and was one not likely to be forgotten. It did not seem possible that eight horses could be transported in a car of that size. This excursion (?) lasted four days and four nights. There may have been worse ways of spending a night in France than riding in a "box-car," but, if so, they were not discovered. It may be said that the story of "Four Nights in a Box-Car" would make that of "Ten Nights in a Barroom" seem more like a comedy than a tragedy. Nevertheless, the trip had its many humorous incidents. The Chaplain, for example, — he spoke French like a native (of China), — gave the boys many happy hours. During a short stop, the Chaplain, by use of the wigwag, semaphore, and his French (?), endeavored to ask a native by-stander the name of a nearby town. The native laughed heartily and replied to his question in choicest English.

Arriving at Neufchâteau on July 30, the men made themselves at home in an old French barracks where there was plenty of room, and no one had to sleep under a crack in the roof. Here were fought the first battles of Vin Blanc and Cognac Hill, with the usual results. In the meantime First Army Headquarters had moved from Neufchâteau to La Ferté-sous-Jouarre (in the Château-Thierry region), and the personnel of Regimental Headquarters was used to organize the Office of Chief Engineer, Second Army.

In this neighborhood the men first learned that there really was a war in France. Eight of them were called upon to drive trucks carrying men and ammunition to the front, and, though this work only lasted a week, they had many an interesting tale to tell when they rejoined their fellows.

During the stay at Neufchâteau, Col. Dent was transferred to the 104th Engineers. This loss was felt very keenly. Capt. Arthur H. Pratt, of Company B, then assumed command of the Regiment.



TRYING TO EAT AND
WATCH AN AIR BATTLE AT THE SAME TIME

In due course, the Office of Chief Engineer, Second Army, including the Regimental Headquarters, 26th Engineers, was mysteriously ordered to change places with the corresponding office of First Army, and on August 13 entrained for La Ferté-sous-Jouarre, going via Chaumont and Noisy-le-Sec (near Paris). The destination was reached in the evening of August 14, and Capt. Knight piloted the men to their new quarters. Entering La Ferté reminded one of the "Great White Way," — it was so different. Not a light was to be seen, nor hardly a sound to be heard. The very evident fact that the railroad station had been recently bombed was mighty impressive.

The next day was spent in establishing the Office of Chief Engineer, who was now called the "Chief Engineer, Paris Group." The "Paris Group" comprised the American troops in the territory around and beyond Château-Thierry. By this time, however, the American troops were being gradually withdrawn and replaced by French troops, — all in preparation for the St. Mihiel drive.

On the second night of the stay in La Ferté, an "alert" was sounded about 10 P.M., by buglers and bells. That meant that a German plane was overhead. The men were watching the searchlights playing over the sky, searching for the plane, when suddenly the Boche dropped a bomb or two and seemed to be coming their way. A mad scramble for a nearby cellar ensued, and it was discovered that 30 men could squeeze through a single doorway at one and the same time, all without the slightest (?) difficulty. A few seconds later a tremendous explosion was heard and felt. Upon investigation (when all had become quiet) it was found that the nearest bomb had exploded about one hundred yards from their billet. During this raid a total of 9 bombs was dropped and several members of the 37th Engineers were killed.

In the earlier days at La Ferté, rations were drawn from the French, and discovery was made of what had become of all the army mules. However, since no one in Regimental Headquarters actually found a horseshoe in his "slum," things went happily. It must be admitted that, when again obtainable, the United States army ration was the more appreciated.

On September 16 migration was resumed. The Office of Chief Engineer, Paris Group, moved to Toul, again becoming the Office of Chief Engineer, Second Army. All members of Regimental Headquarters, with the exception of six enlisted men and two officers, accompanied it. The officers and men left behind were held pending orders to go to Tours, but later received orders to report at First Army Headquarters at Void. Leaving La Ferté on September 22, they entrained for Void, via Château-Thierry, Châlons, Bar-le-Duc, and Toul. At Void they joined the Office of Chief Engineer, First Army, completing the personnel of the Water Supply Service Headquarters.

Here several members rejoined Regimental Headquarters, coming from Second Army. During the stay at Void a complete change in officer personnel was made. Captain Boettger was relieved as adjutant by Lieut. Wells of Company C, and Capt. Shallcross was relieved as supply officer by Capt. Chambers of Company A. Capt. F. W. Scheidenhelm, Water Supply Officer, First Army, and previously attached to the Regiment, was promoted to major and given command of the Regiment. One month later, he was promoted to lieutenant-colonel and continued in command. From about October 1, therefore, Regimental Headquarters played a dual part, being Headquarters for the Regiment and Headquarters for the Water Supply Service of the First Army. Great difficulty was experienced in the administration of the Regiment because the companies were so widely separated. It was well-nigh impossible to get reports of what those companies were doing which were operating in the Services of Supply and in the Second Army. Later the Regiment was equally divided, there being two companies in each of the three armies.

The latter part of October, the Office of Chief Engineer, First Army, moved to Souilly (Meuse), and was followed on October 29 by Regimental Headquarters, now functioning mainly as First Army Water Supply Headquarters. Some of the hardest work, along all lines, was done at Souilly. Here the Supply Department was called upon to play "Santa Claus" to the companies, and undertook the arduous task of outfitting all members of the 26th Engineers with a winter outfit, including, of course, a new uniform. The magnitude of this task can be realized when it is stated that

the Supply Office at this time comprised two officers and four enlisted men, and that, in addition to this, they were, at the same time, looking after the technical supplies for the entire First Army Water Supply Service. Although it has been rumored that the only thing issued to the men of the companies at this time that came anywhere near being a fit were their collar ornaments, still the good intentions of this small force must be considered, and they should be given credit for what they accomplished.

During this time the remainder of Regimental Headquarters personnel was having considerable difficulty in keeping up with the work that was pressing to be done. Unfortunately, the twenty-four hours of each day could not be lengthened. Upon the signing of the Armistice there was joy everywhere, except at Regimental Headquarters at Souilly. It was there that General Sherman's famous remark was revised to read: "War is O.K., but Peace is Hell!" For now it became necessary to record for posterity how it had all been done.

As Christmas time drew near, it was decided that a double banquet should be held in celebration. Regimental Supply Sergt. Chellis was given full charge of "rustling" the one thing essential to all banquets, — food. Four days elapsed without hearing anything from Sergt. Chellis, but on Christmas Eve he telephoned to Headquarters at Souilly. Regimental Sergeant Major Noblit then broke the news to the boys that Chellis had done everything except to secure the "bacon." Things looked bad for having a real Christmas dinner. That night there was a solemn gathering in the kitchen. Every man was armed with a can-opener, while on the tables were neatly arranged tins of "canned William." To the tune of such remarks as, "Well, turkey always did stick in my teeth," all prepared to fall to on the "corned Willy." Just then Sergt.-Major Noblit arrived, saving the day, for with him arrived nine rabbits. Gloom made a silent exit and spirits rose. A little later, Sergt. Chellis arrived on the scene after all, bringing with him turkeys, chickens, and all that goes with them. Thereupon the dreamed-of double banquet became a reality.

About the middle of December word was received for the 26th Engineers to prepare for embarkation for the United States. Of

course this was hard to take. However, everything was cleared up, and on December 29, Regimental Headquarters moved, via trucks, to Verdun, and there, with Companies D and E, it entrained for Bordeaux for the first lap of the homeward journey. The remainder of the Regiment was picked up at Sorcy Gare that night, and for the first time in its history the companies and detachments of the 26th Engineers were together.

The morning of January 2 found the Regiment ready to detrain at Bourg-sur-Gironde. Forty-eight days were spent in this town, awaiting transportation to the States, although even the most pessimistic had been able to find no reason for predicting a longer than three weeks' stay in this town.

During the stay at Bourg an epidemic of influenza caused the death, among others, of Private First Class Abner W. Snow, which was sincerely regretted by all who knew him. This death, occurring on February 7, 1919, was the only one in Regimental Headquarters during the stay in France.

Here, once more, the officers and men of Regimental Headquarters discovered that their work was not completed; again Regimental Headquarters burned the midnight oil. However, since very little was done after midnight, one had all the morning (up to 6 A.M.) to himself.

The above facts having proved conclusively who really won the war, it might be well to anticipate the question, sure to be asked, by stating that no one in Regimental Headquarters knows why two million other men were sent to France. There appears to be more excuse for the other members of the 26th Engineers than for outsiders.

Medical Detachment, 26th Engineers, Bourg-sur-Gironde, France, January, 1919.

REGIMENTAL MEDICAL DETACHMENT.

An accurate account of the activities of the Medical Detachment of the 26th Engineers is difficult of compilation, due to the fact that until the regiment left the front on its long homeward journey the personnel of the Medical Detachment was never together in one place. Previous to that time the Medical Corps men were detailed or parceled out among the several separate commands of the regiment. Thus they shared the troubles and adventures, and helped to ease the ills, of the members of those separate commands.

Taking the regiment as a whole, it may truthfully be said that the standard of health and physical efficiency was high. Due to the class of work for which the regiment was intended, most of the men came from civilian occupations requiring an outdoor life. They were unusually fit and clean — such was frequently the comment of outside medical officers called upon to make inspections at the several embarkation and debarkation ports and camps. Be it said to the credit of the men that, in general, they came back as fit as when they sailed for France. And, aside from the grim effects of the influenza, there were very few deaths from disease among the members of the regiment.

From the medical standpoint the history of the regiment during the stay at Camp Dix was characterized by quarantine after quarantine. The diseases — German measles (brought in by a spy, of course), ordinary measles, and scarlet fever — had no serious results. But, oh! how the quarantines did take the joy out of living! Then there were the inoculations and vaccinations. A " shot in the arm " probably proved to be good preparation for more serious things in France, as well as being a safeguard against the typhoids and smallpox. Unlucky was he who fainted in the process and consequently had to endure the " kidding " of his comrades.

The special physical drill, peculiar to Saturdays and sometimes designated an " inspection," was particularly popular. Conse-

quently the men soon became proficient and could go through it by the numbers. This drill persisted even after arrival abroad and after purely military drill had become secondary in importance.

In France, living conditions were found to be very different from those enjoyed in the homely but comfortable cantonment in the States. Warm quarters were rare. Usually, blanket beds had to be made on stone floors or on damp ground, under a leaky roof, as likely as not. Once at the front, the men perforce spent night after night under the flimsy protection of a " pup " tent or in a leaky, musty, and otherwise inhabited dugout. Often the rats and " cooties " were inherited from previous occupants who had hastily removed toward the Rhine, under American persuasion. The absolutely essential ban on fires at night resulted time and again in continuing dampness of shoes and clothing and blankets.

Such conditions not merely demonstrated the fine physical condition of the men but also proved that morale was high and spirits right. Naturally enough in those days, the daily bills of fare were not selected by expert dietitians; frequently variety was limited or absent. But in general — thanks to the interest of the officers, the care of the mess sergeants, and the faithfulness of ration truck drivers — there was a sufficiency of food. As for the cooks, we " cussed " them at the time, — for want of something better to do, — but " here's to them." Their work was not of the showy sort, yet it bore heavily on health and spirits. They literally made the best out of what there was.

During those days at the front the men of the 26th were scattered in many small detachments. It was impossible for the one medical officer, Major Fricke, to cover all of the ground himself, and so it was incumbent upon the enlisted men of the Medical Detachment to take care of the greater number of the pains and ills that arose. Magnificently did they do their part. But their number, too, was limited, and so some of them had to go back and forth among several details of men. Their mode of transportation was to " hike " or to " hop " a passing motor truck. Special mention may properly be made of Corporal Crikelair, Medical Corps, for his work with Company D in the Bois de Forges. His biggest job was rendering first aid to three men wounded by shell which landed in the kitchen dugout.

The regiment was fortunate in coming through with relatively few battle casualties, considering the fact that working details were usually within the shelled areas. A detailed account of the casualties would only serve to bring back sad memories to those whose less fortunate comrades were the victims.

One casualty, however, may well be set forth here, constituting, as it does, an incident unique in the medical annals of the American Expeditionary Forces: " Red," a sergeant, was brought into the infirmary at 2d Battalion Headquarters, then located west of Verdun at Recicourt. Head bound up, the patient stated that a big shell had exploded very close to him and had knocked out one of his eyes! Such a case is odd, but none the less serious, so the " Corps man " lost no time in preparing the diagnosis tag, ready for evacuating the man to a real hospital in the rear. At this stage, however, " Red " pulled from his pocket the fragments of his eye,— most gruesome! To the diagnosis tag was then added the further note that the eye was — of *glass*. Being hollow, its thin walls had actually been shattered by the concussion of a bursting shell!

After the signing of the Armistice, living conditions naturally became somewhat better; drier quarters were gradually obtainable, and clothing could be dried by fires day or night. With the exception of a few mild cases of influenza brought to Sorcy from Germany by Company F, there was practically no sickness in the regiment until it had been about three weeks in the Bordeaux embarkation area, centering, so far as the 26th Engineers was concerned, about Bourg-sur-Gironde. This was toward the end of January, 1919. At this late date, on the eve, so to speak, of sailing for home, there broke upon the regiment a heretofore avoided epidemic of the dreaded " flu."

For nearly a month the disease held sway, and ultimately a total of five hospital ward tents, together with some smaller tents, were set up to form a field hospital on the beautiful grounds of the château which served as regimental headquarters at Bourg. The commanding officer, Lieut.-Col. Scheidenhelm, himself on sick leave, hurriedly rejoined the organization. Everything possible was done to relieve the sick and to check the epidémic. For those still on their feet there were procured excess allowances of

blankets and clothing. For the sick, through the coöperation of the medical authorities of Base Section No. 2, there came tentage, cots, bedding, and medical supplies. Extra nurses were likewise furnished.

The field hospital was placed in charge of Capt. M. B. Wesson, Medical Corps, who had joined the regiment just before it left the front and greatly aided Major Fricke, regimental surgeon, in carrying the burden. The American Red Cross organization helped mightily, by the loan of nurses and by furnishing special foods. When money was lacking, the several Company funds were freely offered for the benefit of the sick. Then there was Miss Dorothy Gerould, of the Y. M. C. A., who devoted herself unsparingly to the sick. By reason of her cheering attention and her preparation of special "treats" in the way of food or drink, she was a much-appreciated source of aid and inspiration. And one cannot forget our good chaplain who busied himself with and for the sick, the dying, and the dead, day and night.

Trying days were those! It was not until February 10 that the 160th, and last, case was reported. The greatest number of cases under treatment at one time was 90. Yet, everything considered, the death rate was not high. Ten comrades it was that we left in the United States Military Cemetery near Carbon Blanc in the Bordeaux area.

Naturally a feeling of thanksgiving prevailed when on February 19 the entire regiment marched away from Bourg and La Lustre and Plumet, on the 25-kilometer "hike" to the Embarkation Camp at Genicart, with its "mill" and its super-cleansings.

In any tale, even though brief, of the Medical Detachment, one must not fail to mention the Sanitary Corps personnel. Serving in the same general corps of the army, namely, the Medical, they had been attached to the regiment for the especial purpose of dealing with the quality of the water which the Water-Supply Regiment furnished the armies. In their technical work these Sanitary Corps men were likewise scattered all over the front, and had fully their share of hardships. In fact, 1st Lieut. Jos. A. Tinsman, Sanitary Corps, of Company E, was the only officer of the regiment to lose his life. It was on November 4, while the American First Army was pushing strongly toward Sedan, that he was proceeding in charge of a "sterilab" northward from

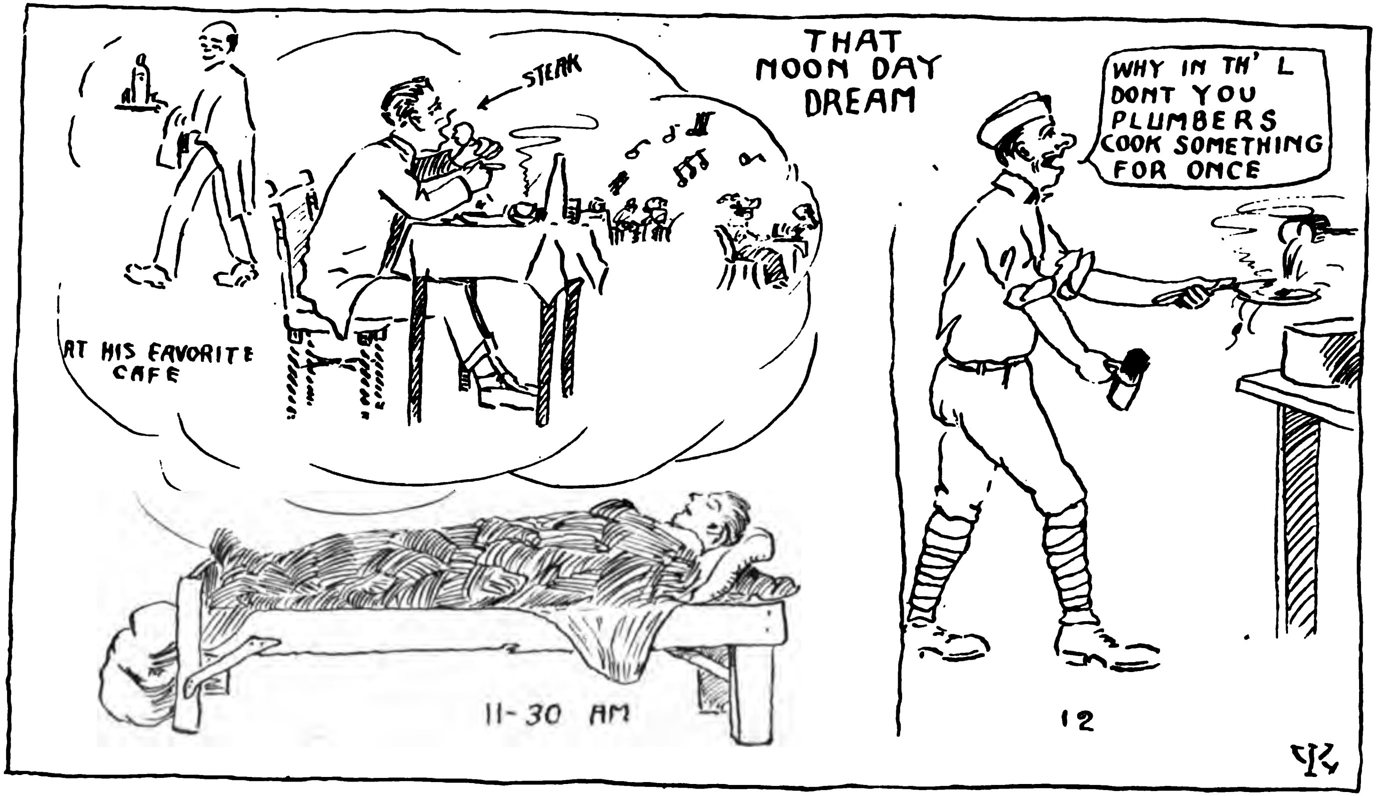
Buzancy along a heavily shelled road. Traffic "jammed" and the shelling continued, but he remained by his charge until a shell fragment struck him in the head. After a brave fight in a hospital, during which he learned of the Armistice, he passed to his own peace, on November 17, 1918.

First Lieut. Hillis, Medical Corps, who was with the regiment at Camp Dix and went to France with the first companies, was

ONE OF THE FEW WATER POINTS DOING SOLELY A "RETAIL BUSINESS."
Hand pump (drawing from stream), Lyster bag with canteen-filling spigots and means for chlorinating water by hand (a duty of the water guard). (Argonne-Meuse offensive.)

soon after arrival transferred to an artillery organization. Hence during the active campaign Major Fricke was the only medical officer with the regiment. Until September, 1918, there had been no dental officer with the regiment. Then 1st Lieut. Vern L. Cowan, Dental Corps, was attached, and filled many an aching void. He continued meeting the neglected needs of the men until the departure from Bourg, when he was torn away to minister unto others not so fortunate as to be homeward bound.

The Medical and Sanitary Corps men were a picked lot, and well qualified for their work. Almost every man was either a college graduate or a student of medicine. Thrown frequently upon their own resources, they served their comrades faithfully and efficiently. By their work they earned a fully proportionate share in the honor accorded the regiment as a whole.


THAT MOON DAY DREAM
STEAK
AT HIS FAVORITE CAFE
11-30 AM
WHY IN TH' L DONT YOU PLUMBERS COOK SOMETHING FOR ONCE
12

THE JOURNEY HOME.

Now, in the twelfth month on the thirtieth day of the month, in the year which saw the downfall of the Hun, were gathered together the six companies of the band of those who furnished water. From the four winds were they assembled; yea, even from the three armies were they called. From the First Army two companies, from the Second Army two companies, and from the Third Army two companies. And they were all in one place in a town called Sorcy, and they were glad, for they were going Home. Had not their captains given orders, saying, each to his company: Let us depart from hence and go elsewhere; there will we meet our comrades whom we have not seen, and when we are together then we will all depart to our homes, yea, then shall each man go to his own house — in due time?

So it happened that when all of the companies were assembled at Sorcy, the men rejoiced and were glad. And they lifted up their voices and sang, even in the mud and in the snow they sang. And these were the words wherewith they showed their joy: Glorious! Glorious! Three firkins of wine for the four of us.

Then said their leaders: Go to! it is not seemly thus to waste time singing. Mount ye into your wagons and let us be gone. But when the men saw the wagons, they were wroth, and spoke one unto another, saying: Is it in these things that we shall ride? Look ye, they are small and few in number, being but thirty and four, and we are many. We shall have no room. It is cold and we have no beds. Let them give us straw to lie upon. The M.P.'s may seek to drive us and more also, but we will not mount. And thus after the manner of soldiers, did they bicker. But amongst the multitude were some of keen eye and deep understanding. And these said: Look ye; Does not each man wish to go Home? Speak not of the M.P.'s. They are *pas bon*. Ye know that we go to the sea and into the vessel prepared for us. See ye not that on the other side of these wagons there are still other wagons filled with straw? Let us mount, and when it is dark then we will salvage straw, *beaucoup* straw, so that every man shall have a bed unto himself.

Then did the men take cheer, and after they were in the wagons, when it was dark did they salvage straw and did make beds, for every man a bed. Only it was one large bed in each wagon whereon all did lie.

Now there were in all, one thousand four hundred two score and three; and the wagons were thirty in number and four for the baggage. So it came about that there was a crowding in the wagons, but none murmured, for they said: We are going Home. Let us be content with our lot. And they were content.

Now about midnight on the thirtieth day of the month, with much noise did they depart. And the wagons were fastened one to another lest any should be lost.

Now it was in the winter-time and cold withal, and some did say: What is this? We are cold and there is no fire wherewith to be warm. Shall we perish with cold while we journey? We will not. Let us buy wine that we may make merry and forget our sorrows. And they did. And the wine was of good flavor and did hold within itself a mighty wallop. And they were warmed. And so throughout the journey some did drink and make merry.

And for two nights and two days and another night did they travel, and, though they were crowded, yet did they not complain, for the journey was a swift one and interesting. Of meat and drink had they plenty; for meat they had willy and for drink *vin rouge* and for bread they had hard cakes of unleavened bread.

So, on the morning of the second day of the first month of the New Year, at the cock-crow did they arrive at Bourg-sur-Gironde, which is hard by Bordeaux.

Now it so happened that beside the wagons at their place of stopping, were many casks of wine. And seeing it, were the men in the nearest wagon glad. And one said to another: Seest thou that which I see? And he said: What seest thou? And the first replied: I see, as it were, much joy. Arise and let us partake; though it is yet early I have a marvelous thirst. And they took two casks within the wagon, and the last state of that wagon was worse than the first. For lo! when the morning came they were all happily irritated and did make merry, one with another. Now when those in command saw what had taken place they cried: This should not be thus. Lo, these men have drunk wine, and

upon strong drink have they looked, and yet have they not offered us of it. Go to, we will make an example of them. For we also have thirst. And they made an example of them and sent them off to prison. And there was peace in Bourg — for a time. And it rained.

But after the men had been taken to their resting places there was a murmuring. And they said: Are we Germans that we should be thrust into barns, or Huns that we should be placed in houses without fires? Let us protest. And straightway they marched upon the hill called Cognac. And they climbed it. And there was a battle. And thus the protest was made. And they called it the Battle of Cognac Hill. And it rained.

Now when the captains and the leaders heard of the battle, upon the hill called Cognac, they said one to another: We must make another example (after we have fought a little ourselves). And having fought a little they sent out men, strong men, to gather up the stragglers. And it was so. And there was peace amidst the rain.

Then did the captains and the lieutenants band together against their men, and did take counsel against them lest the men wax fat and grow lazy in ease. And the days were filled with marches, and they drilled and were given in drills so that they groaned beneath their burden. And it rained.

Now when the inhabitants of Bourg saw how these things came to pass they called together a council. And the wise men assembled and said: Let us take heed, lest we lose much silver. These men will cause much damage. Have they not broken up doors and stairways wherewith to warm themselves? Have they not broken windows? Have they not salvaged much firewood? They have. Go to; we will say naught until the day of their departure, lest they be wroth and buy no more *vin blanc;* but when they go, then will there be a day of reckoning. And even as they had spoken, so it later came about, for the bill was presented, even many bills, and much silver was required of the men, and they were vexed.

The land to which the children of the Water Supply had come was a fair land and a warm one withal. But at times it did rain and they were wet; and on account of this wetness a sickness

descended upon them and many were sick. And when they saw that of this sickness some died, were the men dismayed. But while the sickness was raging there came to Bourg one who did more for the afflicted than many doctors. And the men said: She is as an angel. She goeth abroad speaking cheerily to all; she visiteth the sick and the afflicted. Is she not of our race and does she not speak our tongue? There is none like unto her in all the land. And her presence was like a draught of clear water when the sun shineth hot.

Now among the six companies were two companies of a proud and haughty disposition. For, said one to the other: Are we of the common herd? Are we not better than the other four? Let us leave them to their barns and let us leave that upstart headquarters in the Citadelle and let us *parti*. And they *partied*, one to one city and the other to another, and the names of the two cities are La Lustre and Plumet. And it rained.

Now after a while it happened that one captain spake unto his men words of wisdom; and he opened his mouth and said: O men, it has come unto my ears that there are among you some who fear to place their shirts upon the floor lest they walk away and escape. Now it shall be, that upon the word of command, any man who has this fear shall step forward. And he said unto them: Step; and behold the whole assembly stepped. Then was there a hurrying to and fro, and the wires were kept hot, and a bathhouse was built and a cart bearing the fires of hell was brought, and all the men bathed and put their clothing in the cart, and received it in worse condition than before. And all were happy.

And again the chiefs took counsel among themselves saying: Let us have a parade. And so it came to pass that on an afternoon the men were gathered together on a plain by tens and by hundreds and by thousands, and did march to and fro upon the plain. And the sound of their footsteps was of the sound of a great host marching into battle. And when the sound of the harp and the sackbut, the dulcimer and the cymbal was heard, they did honor to their standard, the most beautiful the world has ever seen; and their hearts were uplifted.

After these things were the men fatigued and they murmured again, saying: When do we go upon the ship? Our souls are weary

of this land. We no longer have work to do and we would depart, each to his own Home. How long, O chief, how long? And once more was there a battle upon the hill called Cognac.

Then said their chief: Have patience; soon will we depart; be of good cheer. And even as he said, so it happened. For on the forty and eighth day of their sojourn they departed. Early in the morning they arose and girded up their loins; and having eaten, they departed bearing their burdens upon their backs. And it rained.

And when they had journeyed all that day they came to a place whereon stood many buildings of wood, and when they saw it they were glad, for they said: On the morrow or the next day or the next will we be on the ship to take us to our own country. This is without a doubt the place called the Embarkation Camp. And they smiled one upon another.

But it was not so, for again upon the morrow, after a night in the buildings of wood, were they called upon to take up their journey. And there was a dissension among them, for said they: Are we not here? Why go we elsewhere? We know not why we go. But they went.

Again they perceived buildings of wood and one, lifting up his eyes unto them while he was yet afar off, spoke, saying: Now know I where we go; that is the place called the Mill. And when they heard this, they were afraid and did whisper among themselves.

Now when they approached this place strange noises were heard, as of souls in torment, so that their knees did shake and their bones become as water. But when they saw men leaving the Mill with clothing disarranged and with heavy burdens on their backs, they said: Are we not men also? Are we not as mighty as these we have seen coming out of the Mill? We are. Let us be of good courage. And they were no longer afraid.

So upon command did they enter and after a space of two hours they began to leave with boots unlaced even as the others. And I spake unto one saying: Tell me, I pray thee, the meaning of all this, and explain to me the mystery of the Mill. And he said: Pause a moment until I collect myself. And when he was collected he lifted up his voice and wept. Then said I: Why weepest


All ye who enter here leave hope behind
WHEN DO WE EAT
9PM
6 P.M
TH' MILL
S-H-O-O-R-E I KNOW
DONT TAKE OFF MUCH.
Before
Gee this razor is dull
THAT x!!x? —? OF A BUTCHER TRY'AN T'CUT HAIR xxx!!
After
NOW THIS IS GERMAN DONT YA' THINK I CAN GET BY WITH IT
KEEP ALL THAT STUFF. YA' GOT T'HAVE SOUVENIRS YA'KNOW
NEEDED IN THE S.O.S.
THOSE RUSSET SHOES

thou? And he said: I weep for my baldness. And lifting up mine eyes I looked and behold he was sheared, even as a shorn lamb.

And when we were seated he took up the burden of his story and said: I will lay bare to thee the secret of the Mill and will expose to thee the mystery of this thing. Behold, when I had entered the door one came and said: Give me thy name and number. And when I had given my name (he already had my number), he gave me a piece of paper bearing writing thereon. And when I looked around I was in a large room with many men and the noise of their voices was as the noise of a tempest. One pushed me and I found myself among them. Two beckoned and when I had approached them with fear and trembling they took my bundle and opened it and did take for themselves my most treasured possessions, my leathern jerkin and my russet shoes. With jokes did they despoil me and with laughter did they bid me go. And I passed to a room many cubits long wherein were pens like those of a slaughterhouse. There one, an evil-looking man, did bid me disrobe. Having done so he opened the door and drew forth a thing of wood upon which he bade me put all my possessions except my three small pieces of silver which I kept in a bag with curious markings upon it. And they did rattle together. The thing of wood bearing my possessions and those of my companions, he put again through the door into a room from which came a roaring as of a hungry lion, and I wondered thereat. Then with shouts he drove us before him to one seated by a bright and dazzling light.

Then spake he who was by the light: Hast thou cooties? Nay; said I. He spake again: Pass on. And with a light heart I hied me to the next room wherein was a sound of running water and much laughter. There I bathed me and made myself clean. With a lightened burden I passed to another room wherein were more bright lights. Here one thumped me on the breast, another looked down my throat, another pierced me with a needle (for what I wot not, but I felt a great dizziness and my nether parts did knock together). Then in a long and narrow room one gave me clothing, another shoes, another a condiment can, according as it was writ on the paper I was given.

After many days, it seemed, I came to another room wherein

were more pens, and when I had seated myself, behold, a door opened and the thing of wood bearing my possessions came out. And now a wonderful thing came to light, for behold, when I touched them they were hot, yea, very hot, for they did seem to burn me. How it came about I know not. Hastily did I put on my clothing, not even having time to touch the latchet of my shoes, for with howls were we driven onward. And now curses be on him who robbed me of my hair, for when I would have left this house of torment, one pulled me to a seat and with swift movements did take my hair and leave me as I am.

And it rained.

Then were there days of anxiety for the men of the Water Supply; then was there gnashing of teeth, for many were called and many were chosen to wield the muck-stick and the banjo. And some did build buildings of wood and buildings of iron. Some did run to and fro upon the face of the earth as messengers, and some did work as K.P.'s. And some did work in the Mill, but on the faces of these was a great joy, for, said they: Now will we avenge ourselves. But of all the workers in the Mill, the one most happy was he who had bewailed the loss of his hair, for said he: At home am I a plumber, but before I return I will have avenged myself greatly. Have I not shorn many, and have I not thereby gained many francs? And he leapt with joy.

And always the chiefs comforted them saying: Peace, 'twill not be long. Even now the vessel to bear ye home is here. But first must ye be inspected by the greatest of us all. And it was so, for on the first day of the third month came the Commander-in-Chief, and from early morning until midday did he inspect them, and he addressed words of praise to them and went his way.

But now a trial came to some, for on the boat prepared there was not room for all, and needs must be that some be left. But those whose lot it was to stay were of good heart and spoke not words of envy, for, said they: Perchance our boat may be swifter than that of these sons of Belial, so let us be of good courage.

And so in the third month of the second day of the month in the first year to follow the ending of the war against the powers of darkness, three hundred two score and four of these mighty men of valor set sail with songs of joy and homecoming on their lips.

And when they were upon the great waters many were sick and they said: Let us die. But they could not, for their sickness lay heavy upon them.

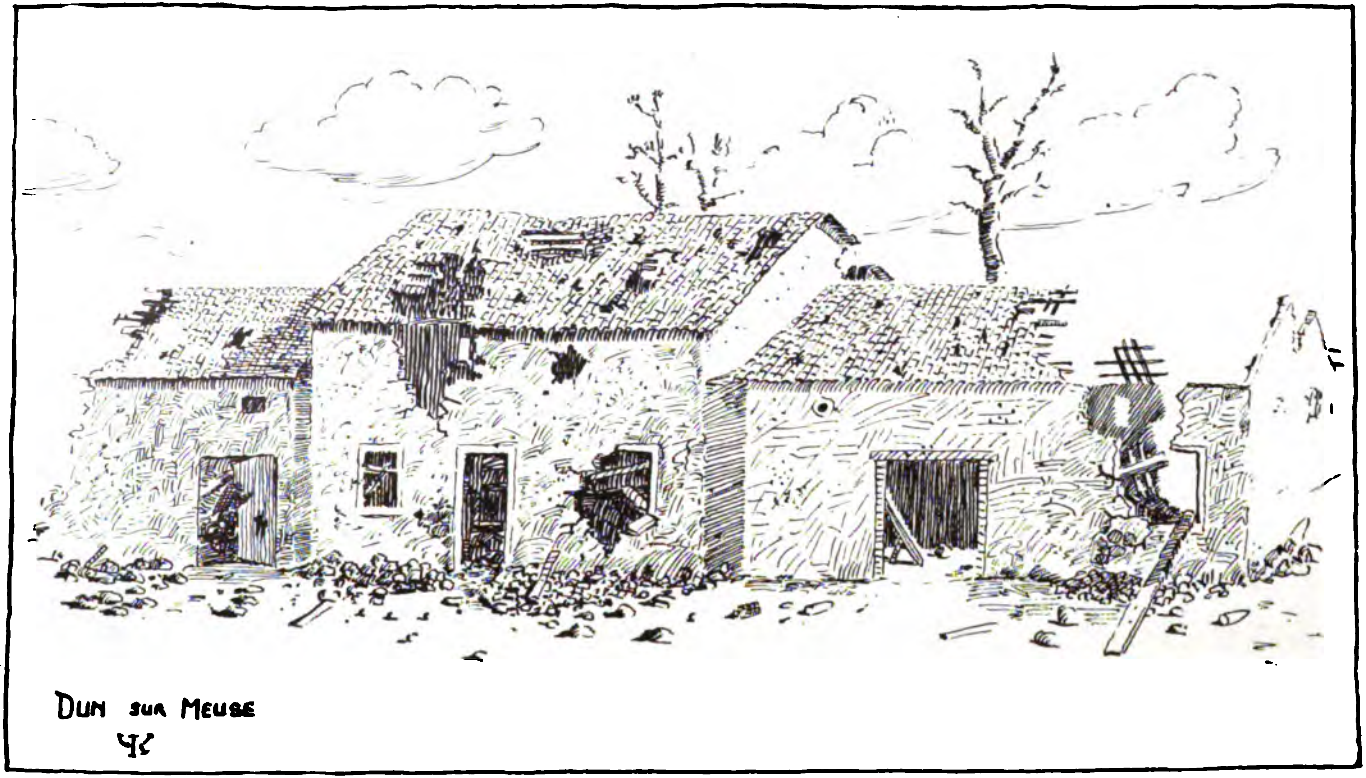
Thus the voyage passed, each day better than the day before, until the last day when there arose a tumult among the captains and the lieutenants and the chiefs, for an order had gone forth forbidding them to wear the most useless of their trappings and the most highly prized. And they said one to another: What manner of thing is this? Shall we throw into discard our Sam Brownes? Go to! we will not. But they did. And when they appeared without their trappings one army nurse spake unto her fellow, saying: Are they not odd? Do they not appear undressed? And there was a great snickering.

And so in the third month on the twelfth day of the month they arrived in the home port, and there were smiles and tears of great gladness. And the men, after the manner of soldiers, said: Never again! When once we see our homes we will not leave again. But each knew in his heart that he spoke from his lips only.

Here endeth the history of the men of the Water Supply. The story of their wanderings ye know and of the works that they did ye know. Of the trials they endured ye know not, for when trials and tribulations cease, do they not seem as dreams? And of their regard for their chiefs ye will not hear for a little time, for again, after the manner of soldiers among themselves, they pleasure in speaking hardly of those in authority.

What ye will hear is of the love of Home, and the love of Country, and a fuller understanding of the duty of man to man.

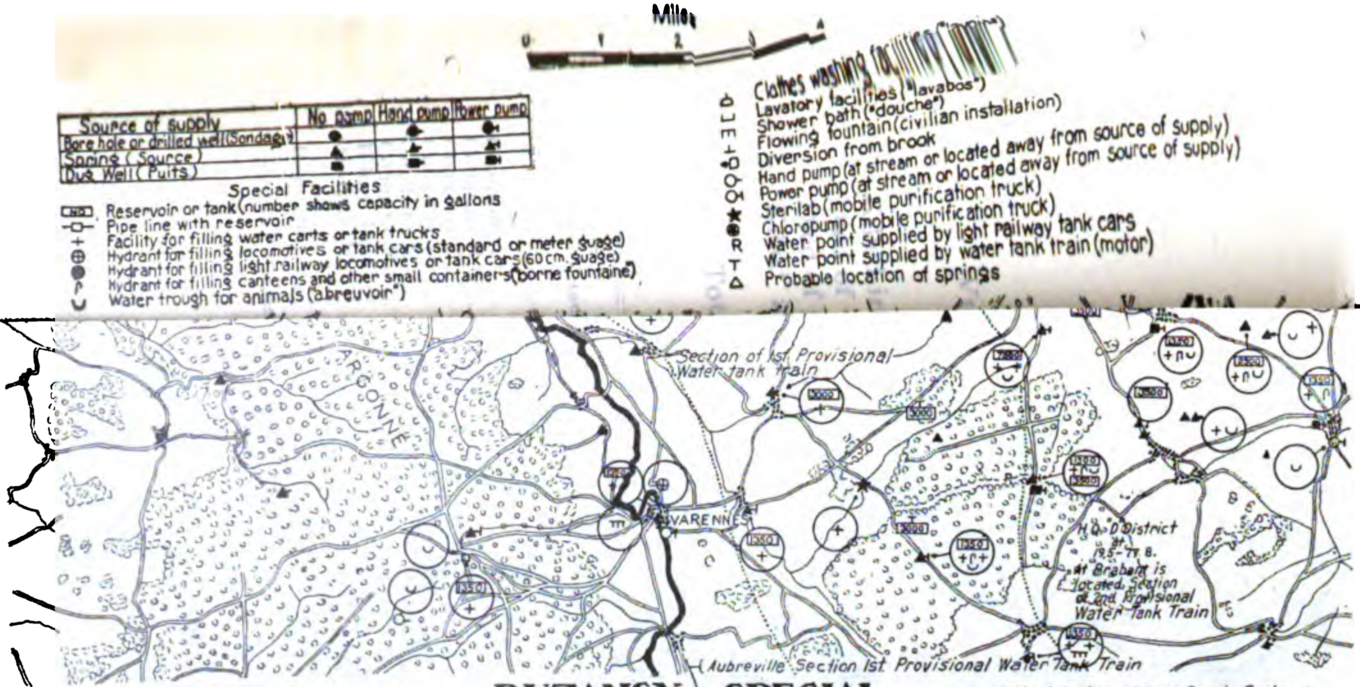
Selah.


DUN SUR MEUSE

Roll of Honor

Name.	Rank.	Organization.	Address.	Date.
[c]Appleby, Thomas F.	Pvt. 1st Cl.	Co. B	Lyme, Conn.	February 29, 1919
[c]Bauerle, Henry G.	Pvt.	Co. A	1400 E. 82d St., Cleveland, Ohio	October 7, 1918
[c]Benedict, William E.	Pvt.	Co. E	Beverly Hills, Calif.	January 25, 1919
[c]Besner, Samuel	Pvt.	Co. C	711 Lyndale Pl. N., Minneapolis, Minn.	February 2, 1919
[c]Burns, Charles C.	Pvt.	Co. A	614 Prairie Ave., Houston, Tex.	February 7, 1918
[c]Davisson, Clarence W.	Pvt. 1st Cl.	Co. E	110 N. Richardson St., Roswell, N. Mex.	January 14, 1919
[c]Dearman, Jim	Wag.	Co. B	Carrizozo, N. Mex.	February 4, 1919
[c]Foster, William F.	Pvt.	Co. B	Willowbar, Okla.	May 18, 1918
[c]Garrity, Hugh	Pvt. 1st Cl.	Co. E	3227 Malabar St., Los Angeles, Calif.	———
[d]Hall, Louis C., Jr.	Sergt.	Co. A	304 Michigan Ave., Owosso, Mich.	December 30, 1918
[c]Hayes, Robert J.	Pvt.	Co. B	719 49th St., Brooklyn, N. Y.	January 30, 1919
[c]Hurley, Thomas F.	Pvt.	Co. D	Syracuse, N. Y.	February 6, 1919
[c]Jerrick, James G.	Pvt.	Co. C	———	October, 1918
[b]Johnson, Fred C. C.	Pvt. 1st Cl.	Co. D	R.F.D. No. 4, Box 99, Fullerton, Calif.	October 28, 1918
[c]Lindley, Paul	Pvt.	Co. B	———	December 4, 1917
[c]Miller, Harry A.	Pvt.	Co. E	2520 N. Saginaw St., Flint, Mich.	December 8, 1918
[c]Mudgett, Orris P.	Pvt.	Co. B	Meredith, N. H.	April 26, 1918
[c]O'Connell, Michael W.	Pvt.	Co. B	Allegany, N. Y.	February 8, 1918
[b]Pelphrey, Joe B.	Pvt. 1st Cl.	Co. D	Oil Field, Calif.	October 28, 1918
[c]Proudfit, M. H.	Pvt. 1st Cl.	Co. E	2015 Sunset Blvd., Los Angeles, Calif.	January 24, 1919
[d]Sharp, Wadley E.	Pvt.	Co. E	Waycross, Ga.	July 31, 1918
[a]Smith, Sam K.	Corp.	Co. E	Cleveland, Tex.	October 10, 1918
[c]Snow, Abner W.	Pvt. 1st Cl.	Reg. Hdqrs.	R.F.D. No. 6, Defiance, Ohio	February 7, 1919
[b]Tankersley, Daniel L.	Pvt.	Co. B	Winchester, Ill.	September 28, 1918
[b]Tinsman, Joseph A.	1st Lieut.	Co. E	Merchantville, N. J.	November 17, 1918
[c]Varetoni, Angelo T.	Pvt.	Co. D	115 Randolph Ave., Clifton, N. J.	February 3, 1919
[c]Wells, Lemuel M.	Pvt.	Co. E	Calio, N. Dak.	February 5, 1919
[c]Whelan, William	Pvt.	Co. A	8004 Kosmak Ave., Cleveland, Ohio	July 7, 1918

[a] Killed in action. [b] Died of wounds received in action. [c] Died of disease. [d] Killed in accident.



Note:- Water Purification Trucks
Available for advance—4. Sterilabs
4 Chloropumps (1 each to go to Semmerance and Romagne)

BUZANCY SPECIAL

SCHEMATIC PLAN OF WATER SUPPLY
ADVANCE OF NOV. 1, 1918.

Materiel: Army Water Supply Park at Dombasle.
Advance W.S. Dumps at each District Hdqrs.

STATISTICS.

VITAL STATISTICS OF 26TH ENGINEERS.

Loss from Regiment by Death.

Killed in action	1
Died of wounds received in action	4
Died of disease	21
Killed in accident	2
Total	28

Strength at Various Dates.

Company or Detachment.	Date of Leaving U. S.		Date of Returning to U. S.	
	Officers.	Enlisted Men.	Officers.	Enlisted Men.
Company A	7	325(*a*)	6	261
Company B	7	310(*b*)	5	229
Company C	7	233	7	202
Company D	7	210	5	207
Company E	6	240	7	205
Company F	7	228	7	218
Hdqrs. Dets	6	38	11	81
Medical Det	2	37	2	31
Regiment	49	1 621	50	1 434

(*a*) Includes 75 men from Specialist Detachment.
(*b*) Includes 76 men from Specialist Detachment.

Company.	Date of Organization at Camp Dix.	Date of Leaving Camp Dix.	Date of Landing in France.	Service with American Expeditionary Forces.			
				Services of Supply.	First Army.	Second Army.	Third Army (Army of Occupation).
Reg. Hdqrs.	Sept. 10, '17	June 22, '18	July 13, '18		Sept. 23, '18 to Dec. 30, '18	July 28, '18 to Sept. 22, '18	
A	Sept. 10, '17	Oct. 28, '17	Nov. 14, '17	Nov. 17, '17 to Sept. 25, '18	Sept. 26, '18 to Oct. 9, '18	Oct. 9, '18 to Dec. 30, '18	
B	Sept. 10, '17	Oct. 28, '17	Nov. 14, '17	Nov. 17, '17 to May 30, '18	Aug. 10, '18 to Oct. 9, '18 (a)	Oct. 9, '18 to Dec. 30, '18	
C	Sept. 10, '17	Mar. 29, '18	April 9, '18	April 21, '18 to Sept. 16, '18	Oct. 2, '18 to Nov. 17, '18	Dec. 20, '18 to Dec. 30, '18	Nov. 17, '18 to Dec. 19, '18
D	Dec. 21, '17	June 22, '18	July 13, '18		Aug. 23, '18 to Dec. 30, '18 (b)	(c)	
E	Feb. 17, '18	Aug. 11, '18	Sept. 2, '18		Sept. 7, '18 to Dec. 30, '18		
F	April 19, '18	Aug. 11, '18	Sept. 2, '18		Sept. 7, '18 to Nov. 16, '18	Dec. 20, '18 to Dec. 30, '18	Nov. 17, '18 to Dec. 19, '18

December 30, 1918. The regiment assembled at Sorcy-sur-Meuse (Meurthe-et-Moselle) and entrained for Bourg-sur-Gironde (Gironde), where it arrived January 2, 1919, and remained in training, awaiting transportation back to United States. February 19, 1919. Marched to Bordeaux Embarkation Camp at Genicart and prepared for embarkation. March 2, 1919. First detachments embarked for the United States. March 24, 1919. The last detachment reached the United States.

Notes. — (a) Service with French Eighth Army, Royaumeix sector; under supervision Water Supply Officer, I U. S. Corps, June 1, 1918, to July 10, 1918, and Water Supply Officer, American First Army, July 10, 1918, to August 10, 1918.

(b) Service with French Eighth Army, Baccarat sector (77th U. S. Division), July 21 to 29, 1918; under supervision Water Supply Officer, American First Army.

(c) Service with French Sixth Army (III U. S. Corps); entire Company, August 4 to 21, 1918, and 2d Detachment continuing to September 10, 1918, under supervision Water Supply Officer, Paris Group. The engineer staff of the Paris Group was later assigned to the American Second Army.

LOCATIONS OF ORGANIZATION HEADQUARTERS.

Regimental Headquarters.

Camp Dix, N. J., September 10, 1917, to June 22, 1918.
Neufchâteau (Vosges), July 30, 1918, to August 12, 1918.
La Ferté-sous-Jouarre (Seine-et-Marne), August 15, 1918, to September 16, 1918.
Toul (Meurthe-et-Moselle), September 18, 1918, to September 23, 1918.
Void (Meuse), September 23, 1918, to October 29, 1918.
Souilly (Meuse), October 29, 1918, to December 28, 1918.
Bourg-sur-Gironde (Gironde), January 2, 1919, to February 19, 1919.
Bordeaux Embarkation Camp, February 19, 1919, to March 2, 1919.
Camp Dix, N. J., March 13, 1919, to March 15, 1919.

Company A.

Camp Dix, N. J., September 10, 1917, to October 28, 1917.
St. Nazaire, November 17, 1917, to December 6, 1917.
Bourmont (Haute-Marne), December 8, 1917, to January 7, 1918.
Daillécourt (Haute-Marne), January 7, 1918, to January 25, 1918.
Montigny-le-Roi (Haute-Marne), January 25, 1918, to April 11, 1918.
Rimaucourt (Haute-Marne), April 11, 1918, to May 18, 1918.
Vittel (Vosges), May 18, 1918, to June 12, 1918.
Les Franchises (Haute-Marne), June 12, 1918, to September 20, 1918.
Commercy (Meuse), September 25, 1918, to October 4, 1918.
St. Mihiel (Meuse), October 4, 1918, to December 20, 1918.
Sorcy-sur-Meuse (Meurthe-et-Moselle), Dec. 20, 1918, to Dec. 30, 1918.
Joined regiment, December 30, 1918.

Company B.

Camp Dix, N. J., September 10, 1917, to October 28, 1917.
St. Nazaire, November 17, 1917, to December 6, 1917.
Bourmont (Haute-Marne), December 8, 1917, to February 12, 1918.
Huilliécourt (Haute-Marne), February 12, 1918, to March 14, 1918.
Humes (Haute-Marne), March 14, 1918, to May 16, 1918.
Les Franchises (Haute-Marne), May 16, 1918, to May 30, 1918.
Lagney (Meurthe-et-Moselle), June 1, 1918, to September 23, 1918.
Grosrovres (Meurthe-et-Moselle), September 23, 1918, to December 20, 1918.
Sorcy-sur-Meuse (Meurthe-et-Moselle), Dec. 20, 1918, to Dec. 30, 1918.
Joined regiment, December 30, 1918.

Company C.

Camp Dix, N. J., September 10, 1917, to March 29, 1918.
Humes (Haute-Marne), April 15, 1918, to April 20, 1918.
Rimaucourt (Haute-Marne), April 21, 1918, to May 17, 1918.
Tours, May 18, 1918, to October 18, 1918.
Ancemont (Meuse), October 21, 1918, to November 17, 1918.
Advance to Coblenz, November 17, 1918, to December 13, 1918.[1]
Wirges (Germany), December 13, 1918, to December 17, 1918.
Sorcy-sur-Meuse (Meurthe-et-Moselle), Dec. 20, 1918, to Dec. 30, 1918.
Joined regiment, December 30, 1918.

Company D.

Camp Dix, N. J., December 21, 1917, to June 22, 1918.
Baccarat (Meurthe-et-Moselle), July 21, 1918, to July 29, 1918.
Fere-en-Tardenois, August 4, 1918, to August 21, 1918.
Griscourt (Meurthe-et-Moselle), August 23, 1918, to September 18, 1918.
Jouy-en-Argonne (Meuse), September 19, 1918, to October 12, 1918.
Bois-de-Forges (Meuse), October 13, 1918, to October 14, 1918.
Bethincourt (Meuse), October 14, 1918, to October 27, 1918.
Bois-de-Forges, October 27, 1918, to November 9, 1918.
Liny-devant-Dun (Meuse), November 9, 1918, to December 27, 1918.
Verdun (Meuse), December 27, 1918, to December 30, 1918.
Joined regiment, December 30, 1918.

Company E.

Camp Dix, N. J., February 17, 1918, to August 11, 1918.
Le Havre, September 1, 1918, to September 4, 1918.
Pompey (Meurthe-et-Moselle), September 7, 1918, to September 17, 1918.
Les Islettes-en-Argonne, September 19, 1918, to October 14, 1918.
Abri du Crochet, October 14, 1918, to October 27, 1918.
Châtel (Ardennes), October 27, 1918, to November 4, 1918.
Buzancy (Ardennes), November 5, 1918, to November 17, 1918.
Verdun (Meuse), November 17, 1918, to December 30, 1918.
Joined regiment, December 30, 1918.

Company F.

Camp Dix, N. J., April 19, 1918, to August 11, 1918.
Le Havre, September 1, 1918, to September 4, 1918.
Sorcy Gare (Meurthe-et-Moselle), September 7, 1918, to September 12, 1918.
Bernécourt (Meurthe-et-Moselle), September 12, 1918, to September 14, 1918.
Pannes (Meurthe-et-Moselle), September 14, 1918, to September 18, 1918.
Auzéville (Meuse), September 22, 1918, to September 28, 1918.
Recicourt (Meuse), September 28, 1918, to October 25, 1918.
Cierges (Meuse), October 25, 1918, to November 5, 1918.
Nouart (Ardennes), November 5, 1918, to November 16, 1918.
Advance to Neuendorf (Germany), November 17, 1918, to December 16, 1918.[1]
Sorcy-sur-Meuse, December 20, 1918, to December 30, 1918.
Plumet (Gironde), January 2, 1919, to February 19, 1919.
Joined regiment, February 19, 1919.

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[1] See Company history for details.

TECHNICAL ACTIVITIES OF 26TH ENGINEERS AS PART OF AMERICAN EXPEDITIONARY FORCES.

SERVICES OF SUPPLY.

Company.	Length of Service. Months.	Work Accomplished.
A	11	20 permanent water-supply installations made at hospitals, aviation camps, barracks, etc. 12 permanent sewerage systems installed at hospitals, including interior plumbing, collecting system, and septic tanks. Miscellaneous work, such as construction of barracks, grading for building sites and roads, quarrying, unloading cars, etc. Receiving, sorting, and shipping of water-supply material and equipment at Gievres Engineer Depot. This included the assembling of 62 well-drilling machines which were shipped completely knocked down.
B	6	11 permanent water-supply installations made at base hospitals, aviation camps, military schools, etc. 2 permanent sewerage systems installed at hospitals, including interior plumbing, etc. Receiving, sorting, and shipping water-supply material and equipment at Gievres and Is-sur-Tille Engineer Depots. Drilling wells in vicinity of Bordeaux and at Bazoilles Hospital. Miscellaneous work, such as construction of barracks, grading, road construction, etc.
C	5	Supervising all varieties of construction, and performing work requiring skilled personnel, at 5 large base hospitals, 4 of which had a capacity of 20 000 beds each. Men filled positions as superintendents, foremen, and timekeepers on construction work, and served as engine and pump operators, electricians, locomotive engineers, master mechanics, truck drivers, and in various skilled trades. Drilling wells at Jouy-le-Tours, Beaune, Allérey, and Brest.

Zone of Armies.

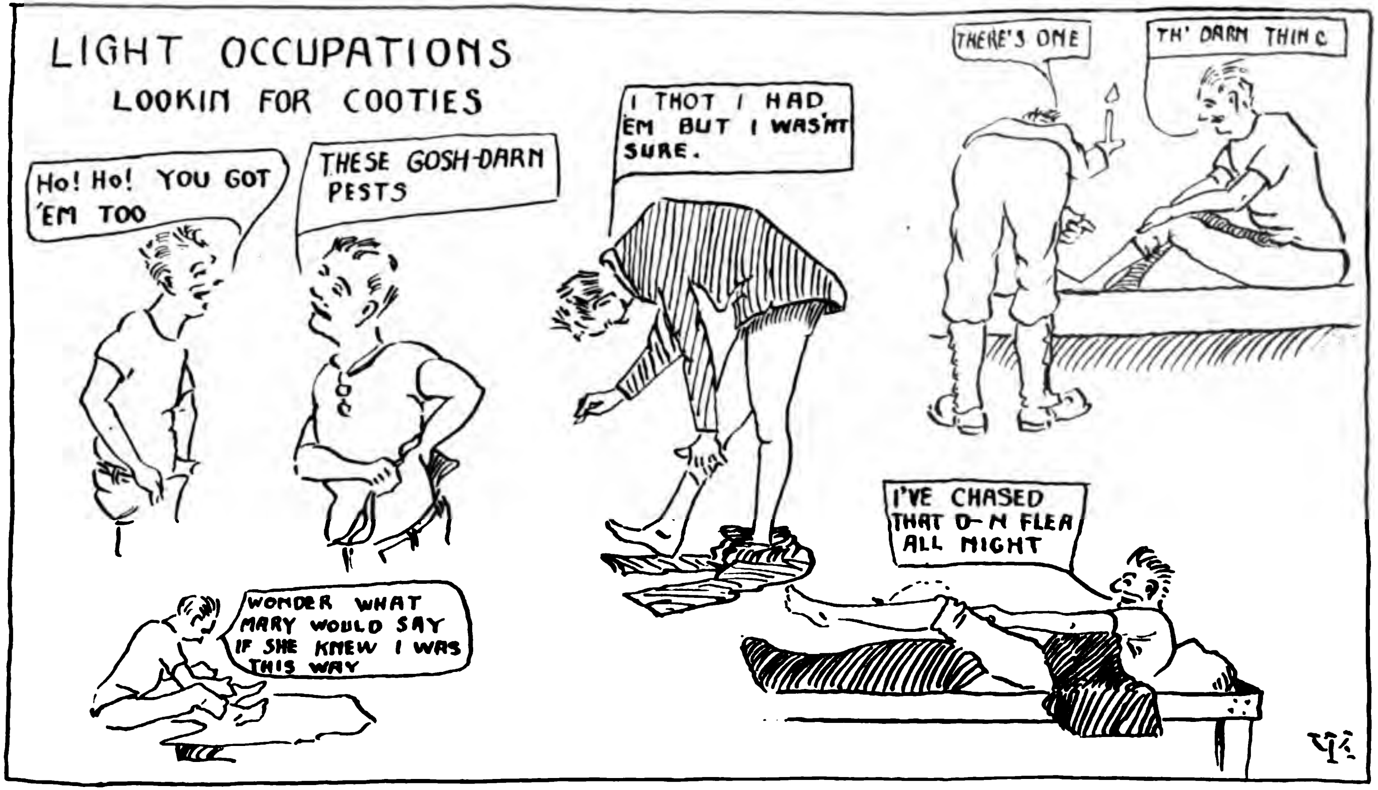
Company.	Organisation Served With.	Military Operation.	Length of Service. Days.	Work Accomplished.
A	First Army.	Organization of occupied territory after St. Mihiel offensive.	13	Construction: 13 water points installed. 10 tanks erected. 9 pumps installed. 4 engines installed. 7 railroad locomotive-filling stations. 4 shower baths installed. 4 old shower baths repaired. 9 500 ft. of pipe laid in connection with all of the above work.
	Second Army.	Same.	82	Operation: 23 pumping plants. 8 water-point patrols. Miscellaneous: During November and December much frost protection work was done. Also 4 000 ft. of pipe salvaged.
B	French Eighth Army (26th and 82d U.S. Divisions). Technical supervision by I U. S. Corps.	Initiation of U. S. Divisions on Toul front.	40	8 pumping stations operated. 2 mobile purification trucks placed and operated. 1 water point installed. 1 concrete tank placed.
	French Eighth Army (37th U. S. Division). Technical supervision by American First Army.	Initiation of U. S. divisions in Baccarat sector.	40 (Part of Company)	4 complete military water points for men and animals. 3 village water-supply systems repaired. 4 000 ft. of 10-in. cast-iron pipe laid, replacing clay main supplying city of Baccarat.

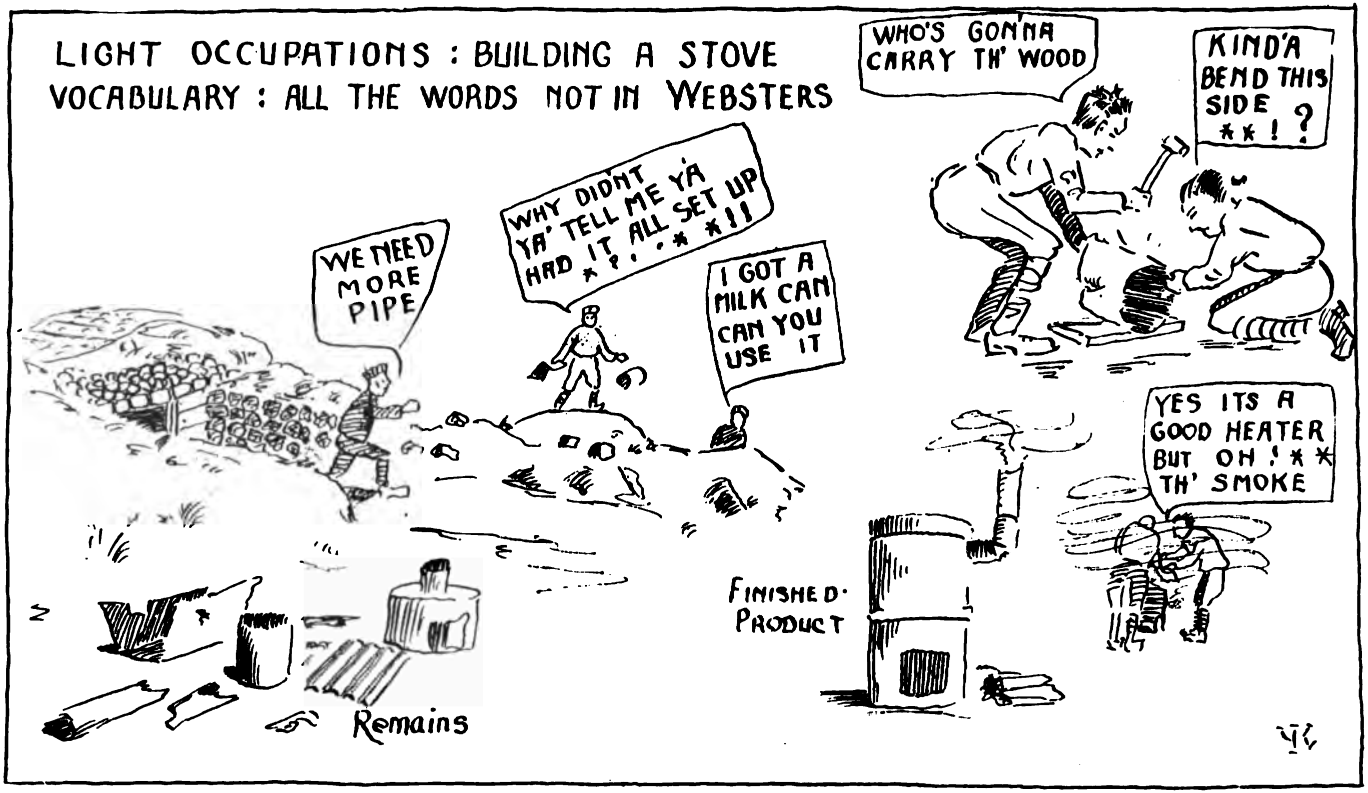
First Army.	St. Mihiel operation.	92	Construction: 8 complete water points, gravity. 17 complete water points, power pump (5 with coagulation and settling basins, filter, etc.) 34 horse troughs (10 of concrete) with water supply and pipe lines. 2 French water points remodeled. 5 German water systems repaired and remodeled (18 000 ft. of pipe traced out). 7 light railway locomotive-filling stations (5 with power pumps). 2 wells drilled. 16 tanks and reservoirs placed or constructed (other than at complete water points listed above). 50 shower bath installations. 2 de-lousing stations. 5 water-supply installations at hospitals. 1 village water-supply system repaired. 4 500 ft. 1-in., 48 000 ft. 2-in., and 22 000 ft. 4-in. pipe laid in connection with all of above work. 57 000 ft. of this was buried beneath the ground. Operation of: Water-supply dump at Leonval. 30 pumping plants at various times. 4 water-purification trucks. 5 complete water-purification plants. Miscellaneous: 1 000 or more water samples taken and analyses made in mobile laboratory. During November and December much salvaging and frost protection work was done.
Second Army.	Organization of recaptured territory after St. Mihiel operation.	82	

ZONE OF ARMIES (*continued*).

Company.	Organization Served With.	Military Operation.	Length of Service. Days.	Work Accomplished.
C	First Army.	Argonne-Meuse operation.	46	Construction: 2 complete water points, involving developed spring, pumping plant, extensive pipe lines, and storage reservoirs. 1 light railway locomotive-filling station. 1 standard gage railway locomotive-filling station. 2 gravity water points with facilities for supplying men. Operation: 15 water points with power pumps, and patrol of 5 groups of gravity water points. Water-supply dump at Rattentout. Made detailed reconnaissance of water resources and existing French water points in area extending northeast from Lemmes-Souilly Road.
	Third Army (1st and 3d Divisions).	March to the Rhine.	32	Marched with Divisional Engineer Troops. Little water-supply work done prior to reaching the Rhine. Reconnaissance work, similar to that performed by Company F, 26th Engineers, was done in the Bridge Head Area.
D	French Sixth Army (III U. S. Corps). Technical supervision under Paris Group.	Organization of territory recaptured during Château-Thierry (Aisne-Marne) operation.	37 (Part of Company)	12 springs or wells cleaned and hand pumps installed. 8 horse troughs erected and supplied with water. 4 gravity water points constructed for furnishing water to men. 4 damaged French water points repaired. 2 bathhouses repaired.

First Army (mainly I Corps).	St. Mihiel operation.	26 (Part of Company.)	Temporary water points: 2 canvas reservoirs. 3 water-purification truck emplacements, 1 with 1 350-gal. tank. Semi-permanent water points with power pumps: 4 complete water points for supplying potable water to men. 6 overhead hydrants for filling water carts at French water points. 1 10 000-gal. concrete reservoir. Large project in Puvenelle Woods carried on and completed, consisting of coagulating basin, 2 triplex pumps in dugout, 15 000 ft. 4-in. pipe, 1 10 000-gal. and 1 2 000-gal. reservoir, 4 cart-filling hydrants, 1 motor-tank filling hydrant, 100 ft. of horse trough, and connection to French horse trough and *lavoir*.
First Army (mainly III Corps).	Argonne-Meuse operation.	103	Temporary water points: 29 springs or wells cleaned out and hand pumps installed with facilities for supplying men and animals. 39 horse troughs installed (970 linear ft.). 11 canvas reservoirs (5 000 gal. capacity). 11 water-purification truck emplacements. Semi-permanent water points: 16 complete water points (power pumps) for supplying potable water to men. 1 light railway locomotive-filling station. 12 standard gage railway locomotive-filling stations. Gravity water points: 11 with facilities for supplying men and animals (8 with brick or concrete reservoirs). NOTE: In connection with all of above work, 360 ft. 1-in., 7 500 ft. 2-in., and 400 ft. 4-in. pipe were laid. Salvaging of water-supply material and equipment during late November and December.

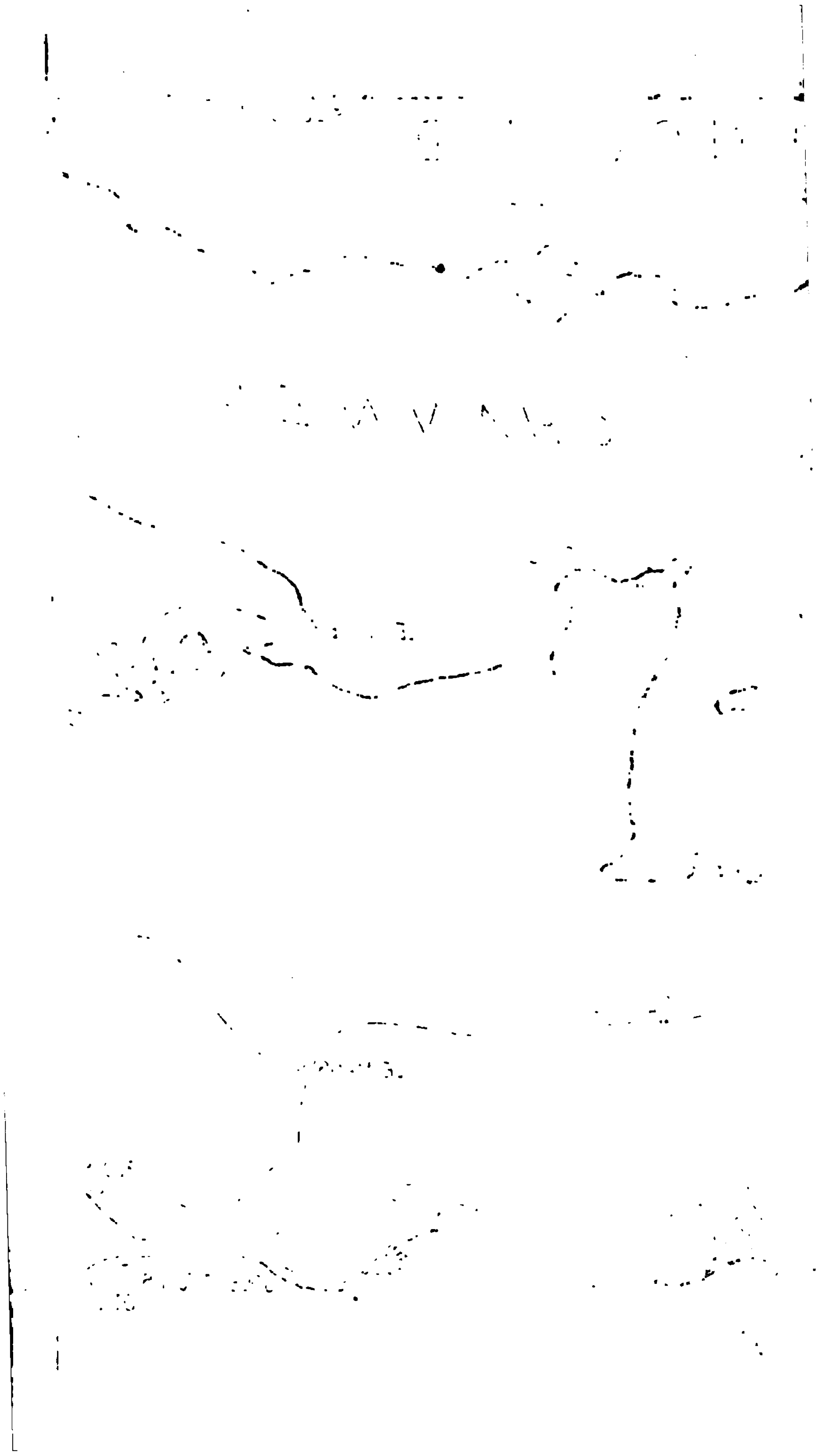

LIGHT OCCUPATIONS
LOOKIN FOR COOTIES
Ho! Ho! YOU GOT 'EM TOO
THESE GOSH-DARN PESTS
WONDER WHAT MARY WOULD SAY IF SHE KNEW I WAS THIS WAY
I THOT I HAD 'EM BUT I WAS'NT SURE.
THERE'S ONE
TH' DARN THING
I'VE CHASED THAT D—N FLEA ALL NIGHT

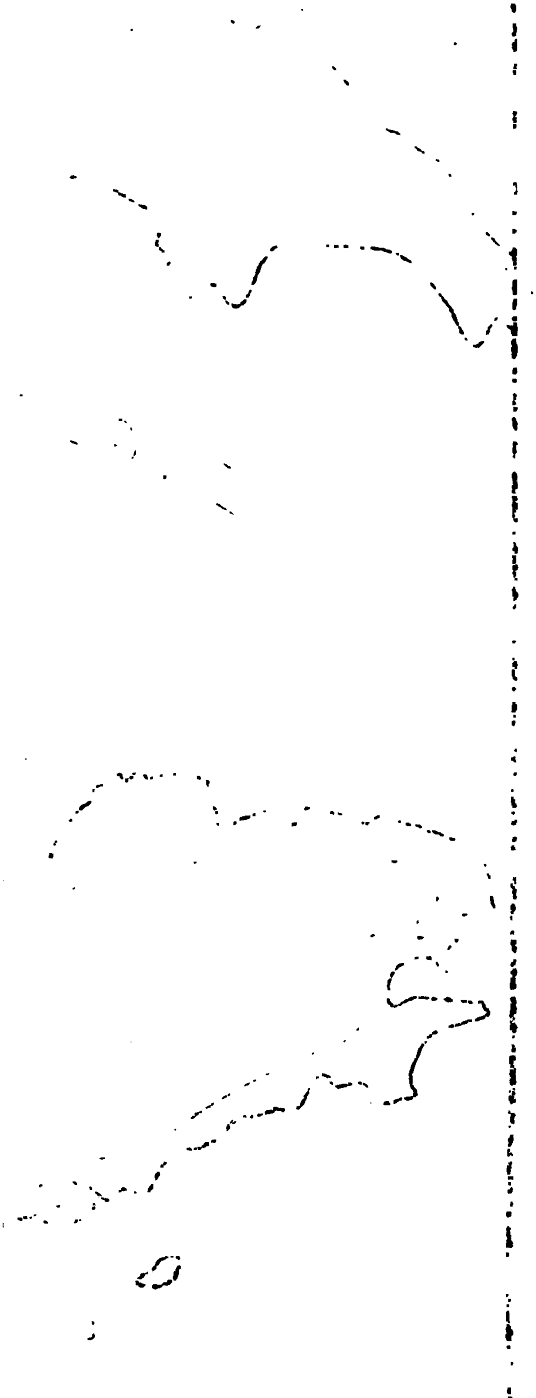

LIGHT OCCUPATIONS : BUILDING A STOVE
VOCABULARY : ALL THE WORDS NOT IN WEBSTERS
WE NEED MORE PIPE
WHY DIDN'T YA' TELL ME YA HAD IT ALL SET UP *?.* *!!
I GOT A MILK CAN CAN YOU USE IT
WHO'S GON'NA CARRY TH' WOOD
KIND'A BEND THIS SIDE **!?
YES ITS A GOOD HEATER BUT OH!** TH' SMOKE
FINISHED PRODUCT
Remains

ZONE OF ARMIES (*continued*).

Company.	Organization Served With.	Military Operation.	Length of Service. Days.	Work Accomplished.
E	First Army (mainly I Corps.)	St. Mihiel operation.	10	Detachment of 75 men and 1 officer attached to D Company, 26th Engineers, acted as water guards at military water points, assisted in installation of canvas reservoirs in Bois de Four, and repaired the damaged water system of Thiaucourt, making 2-cart hydrant connection to the latter.
	First Army (mainly I Corps).	Argonne-Meuse operation.	54	Temporary water points: 9 springs or wells cleaned out and hand pumps installed, with facilities for supplying men and animals. 15 horse troughs installed (460 linear ft.). 8 canvas reservoirs (5 000-gal. capacity). 10 water-purification truck emplacements. Semi-permanent water points with power pumps: 12 complete water points for supplying potable water to men. 3 light railway locomotive-filling stations. 5 standard gage locomotive-filling stations. Gravity water points: 2 with facilities for supplying men and animals (1 with reservoir). NOTE: In connection with all of above work and railway locomotive-filling stations below, 7 200 ft. 2-in. and 2 000 ft. 4-in. pipe were laid.
	First Army.	Subsequent to Armistice.	49	Installing 9 standard gage railway locomotive-filling stations, equipped with power pumps. Salvaging water points in south half of E and F Company areas installed during Argonne-Meuse offensive. Operating 15 water points taken over from Company C on November 17.

F	First Army (mainly IV Corps).	St. Mihiel operation.	12	Temporary water point: 13 canvas reservoirs. 2 horse troughs. 1 hand pump, pipe line, and paved approach. 2 sterilabs placed, with elevated metal tanks 1 350 and 3 000 gal. capacity, 1 250 ft. 2-in. pipe line, and paved approaches. 1 sterilab placed, with paved approach only. Established advance water-supply dump.
	First Army (mainly V Corps).	Argonne-Meuse operation.	58	Temporary water points: 16 springs or wells cleaned out and hand pumps installed with facilities for supplying men or animals. 12 horse troughs installed. 16 canvas reservoirs. 7 water-purification truck emplacements. Semi-permanent water points with power pumps: 15 complete water points for supplying potable water to men. 1 light railway locomotive-filling station. 1 standard gage locomotive-filling station. NOTE: 5 000 ft. 2-in. and 2 000 ft. 4-in. pipe laid in connection with all of above work.
	Third Army (2d and 32d divisions).	March to the Rhine.	32	Water-supply reconnaissance in advance of marching troops, sending back nightly reports for use of division staffs in billeting troops, posting signs showing location and potability of water supplies, cleaning out sources of supply and repairing installations, gathering water samples and performing bacteriological analyses, etc. Parties from each of the two detachments visited daily an average of eight towns and villages situated in the zone of march of the advancing divisions. The detachments advanced by motor trucks.





ORGANIZATIONS WITH WHICH 26TH ENGINEERS WAS ASSOCIATED IN FRANCE.

U. S. Armies.

The 26th Engineers was organized for service with a field army, — that is, to be assigned to an army headquarters and to receive orders directly from the commanding general of an army, as distinguished from a corps or division. Under the conditions which existed in France, it became necessary to divide the regiment, and the various companies served all three of the field armies which were organized as part of the American Expeditionary Forces.

First Army.

Companies B, C, D, E, and F were assigned at various times to this army, and served either in one or both of the two major operations of St. Mihiel and Argonne-Meuse. During the latter offensive, regimental headquarters was also assigned to this army.

Company A also served under First Army for a short period immediately preceding the formation of the Second Army.

Second Army.

Companies A and B served with this army during the period of occupation of the St. Mihiel front, after the successful attack by the First Army.

Third Army (Army of Occupation).

Companies C and F were assigned to this army soon after the signing of the Armistice, and accompanied it on the advance into Germany.

U. S. Corps.

The individual companies of the 26th Engineers serving with field armies were usually assigned responsibility for water supply in areas or districts corresponding with the areas assigned to corps, and close liaison was maintained with the chief engineers of the respective corps. The following list indicates the corps with which such relations were maintained:

U. S. CORPS WITH WHICH 26TH ENGINEERS WAS ASSOCIATED.

Corps.	Company of 26th Engineers.	Military Operation.	Location Company Headquarters.	Dates, 1918.
I	B	Occupation Toul sector.	Lagney.	May 29–July 10.
I	D	St. Mihiel offensive.	Griscourt.	Aug. 23–Sept. 18.
I	E	Argonne-Meuse offensive.	Les Islettes, Châtel, Buzancy.	Sept. 20–Nov. 15.
III	D	Occupation Aisne-Marne area.	Sergy, Coulonges.	Aug. 4–Sept. 8.
III	D	Argonne-Meuse offensive.	Jouy-en-Argonne, Bethincourt, Bois de Forges, Liny-devant-Dun.	Sept. 19–Nov. 14.
III	F	Advance into Germany.		Nov. 17–Dec. 17.
IV	B	St. Mihiel offensive.	Lagney, Grosrouvres.	Aug. 20–Nov. 16.
IV	C	Advance into Germany.		Nov. 17–Dec. 17.
IV	A	Occupation St. Mihiel front.	St. Mihiel.	Oct. 9–Nov. 16.
V	F	Argonne-Meuse offensive.	Auzéville, Recicourt, Cierges, Romagne, Nouart.	Sept. 22–Nov. 17.

U. S. DIVISIONS.

Various companies of the 26th Engineers acting as army water-supply troops had responsibility for water supply in many areas temporarily occupied by combat divisions. Among these divisions were the following:

Division.	Company.	Military Operation.	Approximate Dates, 1918.
1	B and F	St. Mihiel offensive.	Aug. 20–Sept. 18.
1	E	Argonne-Meuse offensive.	Sept. 20–Oct. 15.
1	C	Advance into Germany.	Nov. 17–Dec. 17.
2	D	St. Mihiel offensive.	Sept. 10–Sept. 16.
2	F	Advance into Germany.	Nov. 17–Dec. 17.
3	F	Argonne-Meuse offensive.	Sept. 30–Oct. 15.
3	C	Advance into Germany.	Nov. 17–Dec. 17.
4	D	Occupation Aisne-Marne front.	Aug. 4–Sept. 8.
4	D	Argonne-Meuse offensive.	Sept. 19–Oct. 10.
5	D and E	St. Mihiel offedsive.	Sept. 10–Sept. 16.
26	B	Occupation Toul sector.	May 29–June 30.
28	D	Occupation Aisne-Marne front.	Aug. 4–Sept. 8.
28	E	Argonne-Meuse offensive.	Sept. 20–Oct. 8.
29	D	Argonne-Meuse offensive.	Oct. 5–Oct. 15.
32	F	Argonne-Meuse offensive.	Sept. 30–Oct. 15.
32	F	Advance into Germany.	Nov. 17–Dec. 17.
33	D	Argonne-Meuse offensive.	Sept. 19–Oct. 10.
35	E	Argonne-Meuse offensive.	Sept. 20–Oct. 1.
37	B	Occupation Baccarat sector.	Aug. 4–Sept. 20.
37	F	Argonne-Meuse offensive.	Sept. 22–Oct. 5.
42	B and F	St. Mihiel offensive.	Sept. 9–Sept. 30.
42	E	Argonne-Meuse offensive.	Nov. 5–Nov. 10.
77	D	Occupation Aisne-Marne front.	Aug. 4–Sept. 8.
77	E	Argonne-Meuse offensive.	Sept. 20–Nov. 11.
78	E	Argonne-Meuse offensive.	Oct. 5–Nov. 4.
79	F	Argonne-Meuse offensive.	Sept. 22–Sept. 30.
80	D	Argonne-Meuse offensive.	Sept. 19–Oct. 20.
80	E	Argonne-Meuse offensive.	Oct. 31–Nov. 6.
81	C	Occupation Verdun sector.	Oct. 18–Nov. 17.
82	B	Occupation St. Mihiel sector.	Aug. 15–Sept. 12.
82	D and E	St. Mihiel offensive.	Aug. 20–Sept. 30.
82	E	Argonne-Meuse offensive.	Oct. 8–Oct. 15.
89	B	Occupation Toul sector.	June 30–July 21.
89	B and F	St. Mihiel offensive.	Aug. 26–Oct. 1.
90	D and E	St. Mihiel offensive.	Sept. 12–Sept. 16.
90	B	Occupation Toul sector.	July 21–Aug. 15.
91	D	Argonne-Meuse offensive.	Sept. 22–Oct. 1.
92	B	Occupation Toul sector.	Nov. 10–Nov. 17.

NOTE: Companies C and F were assigned as water-supply troops to the 1st, 2d, 3d, and 32d divisions during the advance into Germany, reporting directly to the division engineers thereof.

U. S. Engineer Regiments.

24th Engineers (Shop).

The operation of approximately 20 unsalvaged pumping plants, previously operated by the 26th Engineers in the St. Mihiel and Argonne-Meuse areas, was turned over to this regiment on December 20, 1918, when the 26th Engineers reassembled preparatory to returning to the United States.

37th Engineers (Electrical and Mechanical).

This regiment was closely associated with the 26th Engineers during the St. Mihiel offensive, when it installed pumps and furnished operators at pumping plants established by the water-supply troops. Due to the insufficient number of the latter available during this offensive and until October 7, 1918, Company D, 37th Engineers, acted as water-supply troops in the Rattentout sector (V Corps area), south of Verdun. During the Argonne-Meuse offensive this regiment installed pumps and furnished operators, but not as extensively as in the preceding attack.

After the Armistice was signed, 1st Lieut. A. B. Fletcher and 40 men from Company E, 26th Engineers, were attached to the 1st Battalion, 37th Engineers, to assist in the investigation and rehabilitation of water stations along the railroad between Conflans and Coblenz on the Rhine. The members of this command were among the very first Americans to reach Coblenz.

27th Engineers (Mining).

Company A of this regiment assisted a detachment from Company B, 26th Engineers, during August and part of September, 1918, when stationed at Baccarat. The work consisted of the construction of water-supply facilities in the Baccarat sector of the Eighth French Army, then occupied by the 77th U. S. Division.

Company B and part of Company A were, during the St. Mihiel offensive, attached partly to Company B and partly to Company D, 26th Engineers, and ably assisted in the construction of water points for the supply of troops engaged in this operation. Their work in constructing dugouts and bomb-proof shelters for pumping plants was particularly valuable.

Water Tank Trains.

1st Provisional.

This water tank train was brought into existence just preceding the St. Mihiel attack as an emergency organization to perform the work of the authorized trains prior to their arrival from the United States. Its equipment and personnel were assembled from the "four corners" of France at a time of great stress, and much

Part of First Provisional Water Tank Train (1 000-gal. Tanks).

credit is due Major M. F. LaCroix, Engineers, Water Transport Officer, whose perseverance and energy were largely responsible for its successful organization. This train served with the 26th Engineers during the St. Mihiel offensive and for a portion of the Argonne-Meuse operation. The following officers were in charge:

2d Lieut. J. G. Garibaldi, Q.M.C., commanding officer.
2d Lieut. O. Hill, Engrs. (Co. B, 27th Engrs.).
2d Lieut. R. Mead, S.C.
2d Lieut. C. D. Smith, Engrs.

The enlisted personnel consisted of Truck Company 311 of the 403d Train, 26 men from Company B, 27th Engineers, and additional men furnished by the Motor Transport Corps, First Army,

— a total of 124 men. These men were separated from their commands and lived and worked under most discouraging conditions. Their work was very difficult and at times dangerous. By their undaunted perseverance and resolution, however, inspired by the practical evidence of the usefulness of their work, the truck trains were kept moving, and drinking water, drawn at pumping stations in the rear, was regularly delivered as far forward as trucks were permitted to go.

2d Provisional.

This water tank train was in every respect similar to the 1st Provisional Train, and performed similar service in adjacent sectors of the front. Its officers were as follows:

1st Lieut. F. S. Altman, Engrs., commanding officer.
2d Lieut. A. Bradford, Engrs.
2d Lieut. B. C. Olmsted, Q.M.C.
2d Lieut. T. P. Jesson, Q.M.C.

The enlisted personnel consisted of Truck Company 3, 23d Engineers, and additional men from a number of different organizations, furnished by the Motor Transport Corps, — a total of 132 men.

301st Water Tank Train.

This organization, comprising 20 officers and 420 men, served with the 26th Engineers in the First Army Water Service during the Argonne-Meuse operation, after its arrival from the United States. The organization reached Clermont-en-Argonne, October 16, 1918, and gradually replaced the 1st and 2d Provisional trains whose personnel was returned to its proper organizations.

302d Water Tank Train.

This organization reached the army zone soon after the 301st Train, and was attached to the Second Army. Company B, commanded by Capt. Higgins, was assigned to the Lagney District and served with Company B, 26th Engineers.

OTHER U. S. ORGANIZATIONS.

59th Pioneer Infantry.

Five companies of this organization were attached as labor troops to an equal number of companies of 26th Engineers during

PUMP STATION AT ST. JACQUES (MEURTHE-ET-MOSELLE).
(St. Mihiel offensive.)

the offensives of October and November, 1918. The officers coöperated fully with the officers of the 26th Engineers during this period of stress, and the most cordial relations existed. Valuable assistance was rendered the water-supply troops under very difficult and, at times, dangerous conditions. The following companies of Pioneers were assigned:

Company C to Company A, 26th Engineers, and Company D to Company B, 26th Engineers, during the period of organizing the territory captured from the enemy in the St. Mihiel attack.

Companies I, K, and M, respectively to Companies E, F, and D, 26th Engineers, during the Argonne-Meuse offensive and the salvage operations immediately thereafter.

542d Service Battalion.

Company A of this organization was attached to Company B, 26th Engineers, during October and November, 1918, and assisted in water-supply construction in the Lagney District.

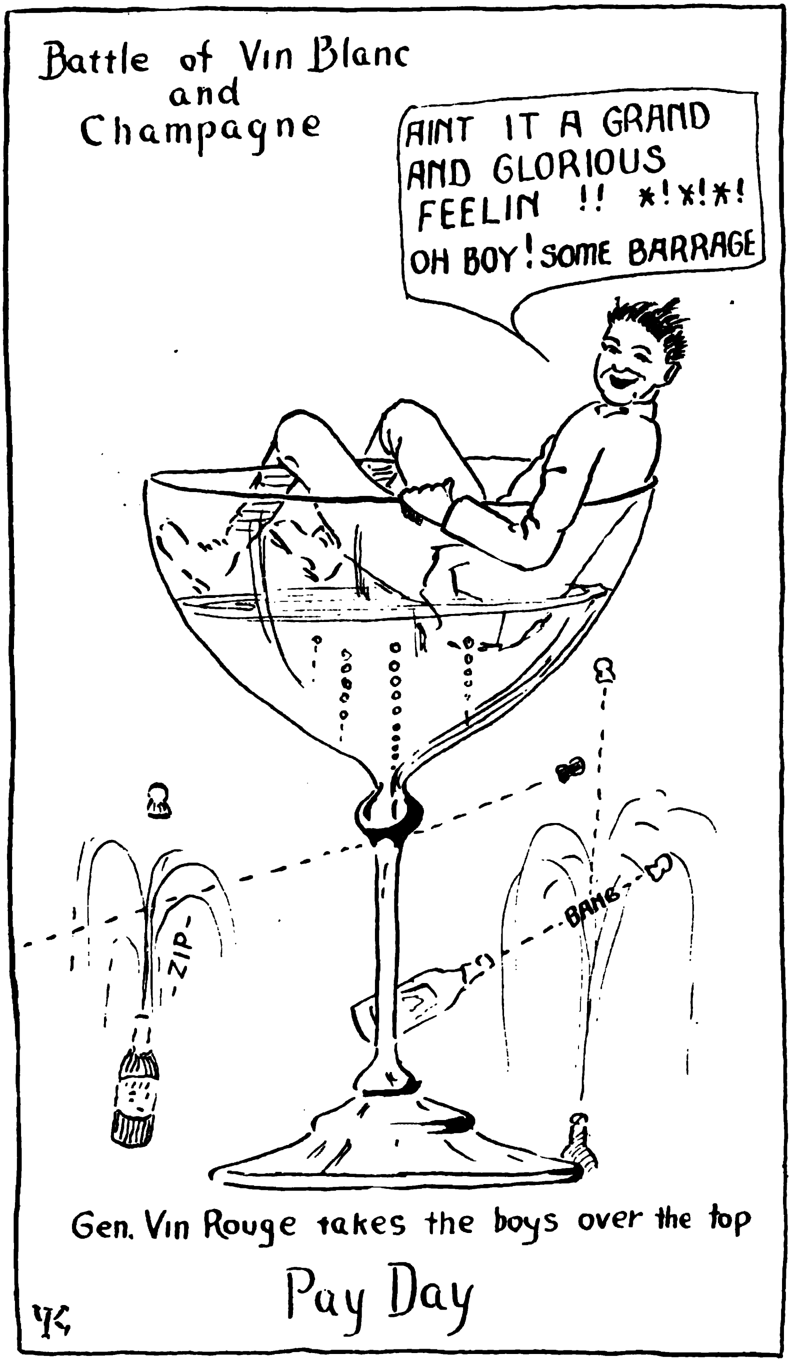
French Organizations.

Service des Eaux, Sixth French Army.

Company D, 26th Engineers, was associated with this organization from August 4 to September 8, 1918, in the III U. S. Corps area south of the Vesle River. Most cordial relations were established between the officers of the Company and Lieut. Bonnevalle, in command of the local French water-supply troops, and it was he who initiated the Company in army water-supply work on an active front. It was here also that Company D had its first experience under shell fire.

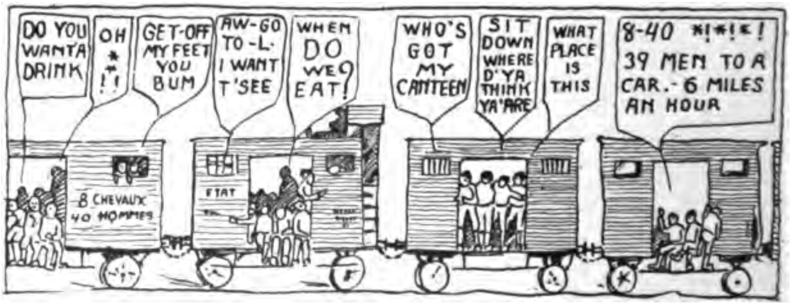
Service des Eaux, Second French Army.

Just preceding and during the Argonne-Meuse operation the officers of the 26th Engineers came into repeated contact with the officers of this service, and most pleasant relations existed. Their assistance at a critical period in furnishing information of the water resources and developed water supplies of the region, and especially in supplying the much-needed tanks, power pumps, and other water-supply material, was deeply appreciated by the officers of the regiment. Among other officers, Lieut.-Col. Parent, Capt. Bailly, and Lieut. Maldidier will long be remembered.


Battle of Vin Blanc and Champagne
AINT IT A GRAND AND GLORIOUS FEELIN !! *!*!*! OH BOY! SOME BARRAGE
ZIP
BANG
Gen. Vin Rouge takes the boys over the top
Pay Day

Service des Eaux, Eighth French Army.

The 26th Engineers was closely associated with this organization for a longer period than with any other of the French military forces. As early as January, 1918, an officer of the regiment visited the Toul sector, spending considerable time with Lieut. Salmon, the local sector water-supply officer, in studying water resources and methods and organization employed in the military water-supply work. Lieut. Salmon was a trained mining engineer, and had had an extended civilian experience prior to the war. He had directed the drilling of many wells in the sector, and had much valuable geologic and well data which he freely made available. Company B, 26th Engineers, was later assigned to the sector, and from June 1 to August 10, 1918, operated with the co-operation of the French, exercised through Lieut. Salmon. Very cordial relations were established during this period. Similar relations existed in the Baccarat sector, with Lieut. Roumégous, where a detachment of Company B was stationed during August, 1918, on water-supply construction work for the 77th U. S. Division. Capt. Salmon, chief of the Service des Eaux, Eighth Army, will also be very pleasantly remembered by the officers who knew him.



WATER SUPPLY SERVICE OF THE AMERICAN EXPEDITIONARY FORCES.

The 26th Engineers formed a very important part of the Water-Supply Service of the American Expeditionary Forces, especially in the Zone of the Armies. It furnished much of the headquarters personnel for the Water Supply Services of the First and Second Armies. The water-supply work in the field was carried on by the various companies of the regiment, assisted by attached labor troops, the Water Tank Trains, and pump operators furnished by the Electrical and Mechanical Regiment. The following extracts from General Orders No. 131, G.H.Q., and Bulletin No. 55, G.H.Q., state clearly the duties and functions of the Water Supply Service and the relation to the Service of the "special engineer troops experienced in water-supply work." The organization chart for the First Army Water Supply Service shows these relations still more clearly, and also the relations of various officers to the Service and to the 26th Engineers.

G.H.Q.
AMERICAN EXPEDITIONARY FORCES.

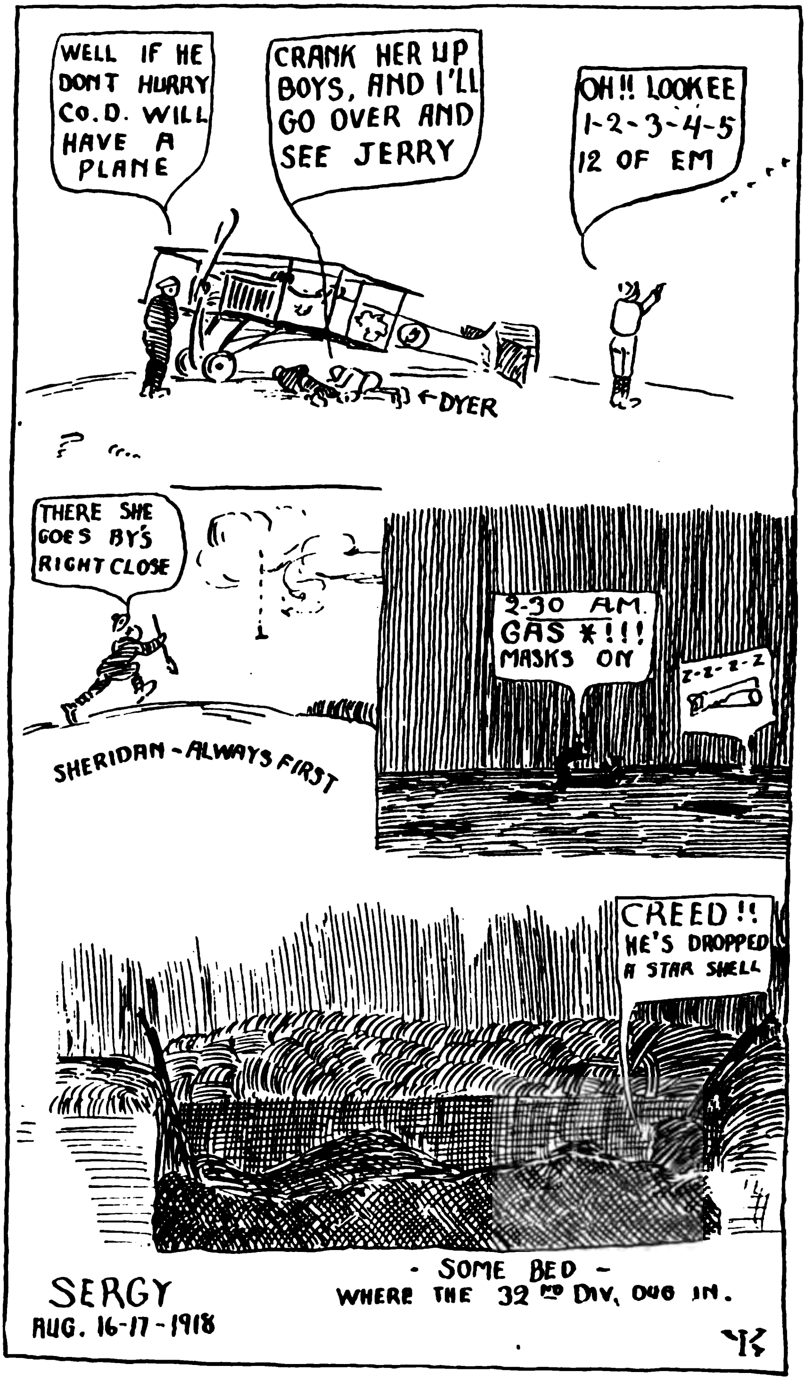
General Orders
No. 131.

FRANCE, August 7, 1918.

I. . . .

2. The responsibility for water supply work for the A.E.F. is divided as follows:

(*a*) In the army zones special engineer troops (water supply) assigned to armies shall be responsible for the supply of adequate quantities of water at "water points" located as conveniently for the troops as service conditions will permit. This water will, if necessary, be purified by filtration or disinfection, or both, in such a manner as to insure the delivery of water of the best quality practicably obtainable under the conditions.


WELL IF HE DONT HURRY CO. D. WILL HAVE A PLANE
CRANK HER UP BOYS, AND I'LL GO OVER AND SEE JERRY
OH!! LOOKEE 1-2-3-4-5 12 OF EM
DYER
THERE SHE GOES BY'S RIGHT CLOSE
SHERIDAN - ALWAYS FIRST
2-30 AM. GAS *!!! MASKS ON
Z-Z-Z-Z
CREED!! HE'S DROPPED A STAR SHELL
SERGY
AUG. 16-17-1918
- SOME BED -
WHERE THE 32ND DIV. DUG IN.

(*b*) In all areas occupied by the American troops outside of army zones, the Engineer Department will be responsible for the development, as required, of water supplies for the use of American troops and for American activities of every kind. This water will be given such treatment as the conditions demand and permit.

(*c*) All water to be used by American troops shall be considered of doubtful quality, and, when required for human consumption, shall be treated, unless proven good by a succession of satisfactory examinations and laboratory tests. Water-analysis laboratory facilities will be provided, generally as sections of the Medical Department laboratories, and will be in charge of officers of the Engineer Department (Water Supply Section), who will conduct examinations and laboratory tests. The proper officer of the Engineer Department will report to the proper officer of the Medical Department the results of water analyses as made.

(*d*) The Medical Department will be responsible for any disinfection treatment that water may require beyond "water points," and, to prevent contamination and pollution, will supervise its handling and the care of containers so that the water will finally be safe for consumption by troops.

. . . .

By command of General Pershing:

JAMES W. MCANDREW,
Chief of Staff.

Official:
ROBERT C. DAVIS,
Adjutant-General.

G.H.Q.
AMERICAN EXPEDITIONARY FORCES.

Bulletin
No. 55.

FRANCE, August 8, 1918.

A. — ORGANIZATION OF WATER SUPPLY SERVICE.

1. The Water Supply Service of the American Expeditionary Forces is organized as a branch of the Engineer Department. It consists of certain officers and special engineer troops experi-

enced in water-supply work, including examinations, design and construction. Its duties are defined by Sec. I, G.O. No. 131, G.H.Q., A.E.F., 1918.

For each army the Water Supply Service will consist of army engineer troops (not to exceed one regimental headquarters and six companies), especially trained and equipped for water-supply work, and such additional officers as conditions may require.

In general, the functions of the army water-supply organization will include the investigation of water resources, the development of water supply, and the construction and operation of such works as may be necessary to make water available at "water points," including conveniences for watering animals, filling water carts, water-tank trains, buckets, canteens, and other containers. Tactical units will make provision for the transportation of water from "water points" to the final point of consumption.

The commanding officer of the Water Supply Regiment will normally be the Water Supply Officer of the army, serving as an assistant to the Chief Engineer of the army. He will anticipate and make suitable provision to meet the water-supply needs of the army, and will exercise such technical supervision and control over water-supply work in the entire area occupied by the army as may be necessary to coördinate water-supply developments and economize time, material, and labor. Under the direction of the Chief Engineer of the army he will direct laboratory and sanitary inspections necessary to determine potability and to prevent contamination.

Under the direction of the Chief Engineer of the army, the work of installation, maintenance, and repair of power pumping equipment incidental to the development of "water points" will be done by engineers of the electrical and mechanical or other units according to conditions, but such equipment will be operated in accordance with the requirement of the water-supply organization.

Water-supply troops are army troops as differentiated from division or corps engineer troops. When working in army areas they will perform their work and be under the direct control of the Chief Engineer of the army acting under instructions from Army Headquarters. To properly perform their duties, water-supply troops must acquire an intimate knowledge of the area in

which they are to operate, and must be thoroughly familiar with layout and mechanical details of water-supply installations serving the area. In the interests of efficiency, therefore, these troops should be used continuously in the same sector and on the same class of work, in so far as other military requirements will permit. They will not be moved except upon instructions from Army Headquarters.

When operating within sectors assigned to corps, division, or other tactical commands, the relation between water-supply troops and other engineer organizations of these commands will be the usual relation existing between army troops and corps or division troops, namely: Officers of the Water Supply Service, when in local charge of work lying within the territorial jurisdiction of these commands:

1st. Will at all times be prepared to furnish, upon request by corps or division engineers, information concerning their work in hand and future projects.

2d. Will secure the approval of corps or division engineers upon questions of installation and operation, as far as tactical considerations are involved, but will report direct to the Chief Engineer, Army, upon all technical matters.

3d. Will, upon request, advise corps and division engineers on technical matters pertaining to the Water Supply Service, and perform such technical work as may be consistent with the work assigned to them by the Chief Engineer, Army. Whenever the performance of work requested by corps or division engineers will conflict with work already assigned by the Chief Engineer, Army, or known to be under immediate consideration, the local water-supply officer will, before proceeding, request approval from the Chief Engineer, Army, and will advise the corps or division engineer of action taken, and the reason therefor.

Nothing in these instructions shall be construed to deprive the commanding officer of the corps, division, or other command, of the authority that is fundamentally vested in him, such as police and traffic control, arrangements for subsistence and supply, and enforcement of measures for safety.

. . . .

ORGANIZATION COMMANDERS.

26TH ENGINEERS.

AT DATE OF EMBARKATION FOR FRANCE.	AT DATE OF EMBARKATION FOR UNITED STATES.
Col. E. J. Dent, Engrs., Regimental Commander.	Lieut.-Col. F. W. Scheidenhelm, Engrs., Regimental Commander.
Capt. Robert Boettger, Engrs., Adjutant.	1st Lieut. Fred S. Wells, Engrs., Adjutant.
Major A. A. Fricke, Med. Corps, Medical Detachment.	Major A. A. Fricke, Med. Corps, Medical Detachment.
(Battalion organization not authorized until November, 1918.)	Major Arthur H. Pratt, Engrs., 1st Battalion.
	Major Dwight Horton, Engrs., 2d Battalion.
Capt. H. E. Chambers, Jr., Engrs., Company A.	1st Lieut. P. O'B. Montgomery, Engrs., Company A.
*Capt. Arthur H. Pratt, Engrs., Company B.	1st Lieut. Warren G. Baxter, Engrs., Company B.
Capt. Geo. W. Stickney, Engrs., Company C.	Capt. Geo. W. Stickney, Engrs., Company C.
Capt. John C. Pritchard, Engrs., Company D.	Capt. T. B. Parker, Engrs., Company D.
Capt. Arthur Knapp, Engrs., Company E.	Capt. John C. Pritchard, Engrs., Company E.
Capt. Dwight Horton, Engrs., Company F.	1st Lieut. Fred J. Stewart, Engrs., Company F.

* Major (then Captain) Arthur H. Pratt, being temporarily senior officer actually serving with the troops in France, acted as regimental commander November 17, 1917, to July 18, 1918, and July 29 to October 3, 1918.

TO - L - WITH THE PIPE COME ON
GET OVER THE HILL BOYS
HOT DOG !! SNAP IT UP CAP
STRAGETIC RETREAT OF C°D
-CHATEAU THIERRY -
OUR BAPTISM OF SHELLS

BIOGRAPHICAL SKETCHES OF FIELD OFFICERS.

COL. ELLIOTT J. DENT, *Engineers.*

Elliott Johnstone Dent was born November 1, 1877, at Brookland, Pa. He attended the Episcopal High School, Alexandria, Va., 1889 to 1895; Columbian University (now George Washington University), Washington, D. C., session 1895–1896; and the United States Military Academy, West Point, N. Y., 1897 to 1901.

He was appointed second lieutenant, Corps of Engineers, to date from February 2, 1901; first lieutenant, June 4, 1903; captain, July 6, 1908; major, February 27, 1914; colonel, National Army, August 5, 1917. From March, 1901, to April, 1905, he was on duty with engineer troops, including garrison duty at Fort Totten, N. Y., and Washington Barracks, D. C., and two and a half years' field duty in the Philippine Islands. He participated in the Moro campaign of 1902, in Mindanao.

From 1905 to September, 1917, he was engaged on various duties including work on the Washington Filtration Plant, Washington Aqueduct, Government Pier for the Jamestown Exposition, and river and harbor work in various districts. Also he served four years with engineer troops at Vancouver Barracks, Wash.

During the first summer of the war, 1917, his duties included examination of applicants for commission in the Engineer Reserve Corps at Portland, Ore., and Seattle, Wash., and applicants for enlistment in the 18th Engineers. On August 31, 1917, he was appointed colonel, Corps of Engineers, National Army, and assigned to command the 26th Engineers at Camp Dix, N. J., August 31, 1917. In this capacity he supervised the organization of both the 24th and the 34th Engineers, for these in their early stages were attached to the 26th Engineers for purposes of instruction and discipline. He sailed for France with the Headquarters, 26th Engineers, June 30, 1918. Shortly after arrival he was, on July 29, 1918, relieved from duty with that regiment and assigned to command the 104th Engineers and to serve as division engineer, 29th Division.

With the 104th Engineers he took part in the Argonne-Meuse offensive from September 28 to October 28, 1918. During the first half of this period, the 104th Engineers were serving as corps troops, near Avocourt, and during the latter half they were with the 29th Division in their offensive east of the Meuse River, near Samogneux. On January 15, 1919, he was relieved from the 29th Division and assigned as division engineer, 4th Division, commanding the 4th Engineers. The 4th Division was then in the Army of Occupation in Germany. In March, 1919, he returned to the United States and was placed on duty in the New Orleans Engineer District.

He was awarded a United States Army citation for exceptionally meritorious and conspicuous services as division engineer, 29th Division, April 19, 1919.

COL. FRANCIS F. LONGLEY, *Engineers.*

Francis F. Longley was commissioned in July, 1917, as a major of Engineers, and in the following month was ordered to France. In November, 1917, he was promoted to lieutenant-colonel and assigned to the 26th Engineers. In October, 1918, he was promoted to fill the vacancy of colonel, 26th Engineers. His entire period of service has been with the water-supply organization of the American Expeditionary Forces, in the dual capacity of colonel of the 26th Engineers, Army Water Supply Regiment, and chief of the Water Supply Section, Office of Chief Engineer, A. E. F.

Colonel Longley was born of American parents, on October 23, 1879, at Chicago, Ill. He was graduated from the United States Military Academy in 1902 and was commissioned in the Corps of Engineers. Soon after, he resigned, and during the winter of 1903–1904 he pursued post-graduate studies at Massachusetts Institute of Technology. Prior to entering the service in 1917, he was engaged in the practice of civil, hydraulic, and sanitary engineering in New York City.

Colonel Longley's professional experience in civil life has been as follows: Assistant on various engineering works, design and construction of water-supply and sewerage works, mill buildings, hydraulic works, two years; in charge of operation of water-

purification plants, including laboratory work, Moline, Ill., Watertown, N. Y., Washington, D. C., four years; in charge of investigations and report on project for increasing the water supply of Washington, D. C., 1908–1909; in charge of construction of water-purification plant for Toronto, Ont., 1909–1912; work on other improvements for Toronto water-supply system, 1912–1913; consulting engineer, 1913 to 1919, member of firm Hazen, Whipple & Fuller, engaged on various water-supply, sewerage, and sanitary projects. In November, 1919, he sailed for Europe to become Associate Director of the Division of Sanitation in the Bureau of Hygiene and Health of the League of Red Cross Societies, with headquarters at Geneva, Switzerland.

LIEUT.-COL. FREDERICK W. SCHEIDENHELM, *Engineers.*

Frederick W. Scheidenhelm entered the First Officers' Training Camp and was commissioned as captain of Engineers June 19, 1917. After a short period of service with the 303d Engineers at Camp Dix, N. J., he was ordered overseas in October, 1917. He was promoted to the rank of major, September 21, 1918, assigned to the 26th Engineers, and automatically became commanding officer of the regiment. On October 21 he was made lieutenant-colonel, still in command of the 26th Engineers, and continued thus until the regiment was mustered out. His period of service in France was largely with the Water Supply Service; first in the Office of Chief Engineer, at G.H.Q.; from March 20 to June 20, 1918, as assistant to the Chief Engineer, I Corps, at Neufchâteau; and finally as Water Supply Officer, First Army, in which position he served until November 20, 1918.

In his capacity as Water Supply Officer, he directed the work of the First Army Water Supply Service during the St. Mihiel and Argonne-Meuse operations. This service included a maximum of 115 officers and 3 450 men.

Subsequent to his discharge from service for the emergency, he was commissioned as colonel in the Engineer Officers' Reserve Corps, U. S. Army.

Lieut.-Col. Scheidenhelm was born June 16, 1884, at Mendota, Ill. He graduated from Cornell University, receiving the degree

of A.B. in 1905 and C.E. in 1906. He engaged in the practice of structural and hydraulic engineering during the following years, first at Pittsburgh, Pa., and, subsequent to January, 1916, at New York.

His professional experience prior to entering the service is as follows: With West Penn Railways Company, first as structural engineer in charge of design and construction of reënforced concrete bridges and transmission line towers and also a steam-power plant, and later as hydraulic engineer on investigation of water-power projects, four years; making water-power investigations for Pittsburgh Hydro-Electric Company, of which he was secretary-treasurer and chief engineer, and also independent consulting work of the same character, two years; chief engineer, Hydro-Electric Company of West Virginia, in charge of engineering, legal, and real estate work for Cheat River, Big Sandy Creek, and Blackwater projects, and the reconstruction of the Stony River Dam of the West Virginia Pulp & Paper Company, four and a half years; consulting engineer since January, 1916, member of the firm of Mead & Scheidenhelm, New York City, handling hydroelectric, water-supply, irrigation, drainage, and flood-control developments.

Major Arthur H. Pratt, *Engineers.*

Arthur H. Pratt attended the Plattsburg Training Camp in 1916, and after completing the Parker Instruction Course for Reserve Officers was commissioned captain in the Engineer Officers' Reserve Corps, January 22, 1917. He was ordered to active duty at the Officers' Training Camp, Ft. Oglethorpe, Ga., in May, 1917, and subsequently assigned to the 26th Engineers at Camp Dix, N. J., where he reported September 4, 1917. He served as commanding officer of Company B, and upon leaving the United States in October, 1917, by virtue of being senior officer he became regimental commander in the American Expeditionary Forces. He continued in this capacity, with the exception of eleven days in July, until October 3, 1918, at which time Major F. W. Scheidenhelm assumed command. He was promoted to the rank of major, October 25, 1918. He served as

officer in charge, Water Department, Office of Chief Engineer, Second Army, from early August, 1918, until the 26th Engineers began to assemble, December 20, 1918, for transportation to the United States.

Major Pratt was born of American parents at Marlboro, Mass., on July 9, 1874. His technical education was received at Lowell Institute, Boston, and Brooklyn Polytechnic Institute. Prior to entering the service he was engaged in civil and hydraulic engineering work in New York City.

His professional experience in civil life is as follows: Assistant on engineering work with the Metropolitan Sewerage Commission of Massachusetts, and later the Engineering Department of the town of Brookline, Mass., ten years; with the War Department on river, harbor, and lighthouse work at Philadelphia, two years; assistant division engineer on the Catskill Aqueduct for the city of New York, eight years; and engineer on sewerage work for New York City with the New York Sewer Plan Commission, Board of Estimate and Apportionment, and finally with the borough of Manhattan, three years.

MAJOR DWIGHT HORTON, *Engineers.*

Dwight Horton was commissioned as captain of Engineers, August 17, 1917, and was ordered to Officers' Training Camp, January 5, 1918. After six weeks of training he was designated construction quartermaster at Camp Bowie, Tex., during the period of active construction. On April 15, 1918, he was assigned to the 26th Engineers at Camp Dix, N. J., and given command of Company F. He served in this capacity until September 15, 1918, when he was designated Water Supply Officer, Northern District, First Army, during the Argonne offensive. He later took command of the 2d Battalion, 26th Engineers, serving in that capacity until the regiment was demobilized at Camp Dix, N. J., March 14, 1919. Late in February, 1919, he received promotion to major of engineers.

Major Horton was born November 17, 1881, at Buffalo, N. Y. His parents were of American descent. He received his early education at El Paso, Tex., and a technical training in civil engi-

neering at the University of New Mexico. His early technical experience was on railroad work, as locating and construction engineer, in New Mexico and the Southwest. Subsequently he was engaged as designing and construction engineer on municipal improvements, public roads, and bridges. During the ten years preceding his entry into the service, he carried on extensive contracting operations, including municipal, irrigation, building, dock and wharf, road and bridge construction throughout the Southwest and the Mississippi Valley.

MAJOR ALBERT A. FRICKE, *Medical Corps.*

Albert A. Fricke was commissioned first lieutenant in the Medical Reserve Corps in 1912 and captain, M.R.C., in May, 1917. He served from June to September, 1917, at the Medical Officers' Training Camp at Fort Riley, Kan. He was assigned to the 26th Engineers as regimental surgeon, September 12, 1917, and continued in this capacity until the regiment was demobilized, March 14, 1919. He was promoted to the rank of major, May 25, 1918.

Major Fricke was born November 12, 1878, at Mound City, Ill. He received the degree of A.B. in 1906 from the University of Nebraska, and in 1908 the degree of M.D. from the medical department of the same institution. He later supplemented his professional education by doing post-graduate work in Berlin and Vienna during 1913.

His professional experience prior to being ordered to active duty is as follows: Interne, Methodist Hospital, Omaha, Neb., two years; practice of general medicine at South Side, Omaha, nine years. During this period he was local surgeon for the Union Pacific, Burlington and Chicago, Rock Island & Pacific railroads; local examiner for thirteen insurance companies; and on the staff of the South Side General Hospital.

OFFICERS OF 26TH ENGINEERS DETACHED FOR SPECIAL DUTY IN FRANCE.

COL. F. F. LONGLEY, *Engineers.*

Officer in Charge, Water Supply Section, and Assistant to Director of Division of Military Engineering and Engineer Supply, Office of Chief Engineer, American Expeditionary Forces, in which capacity he had technical supervision over all water-supply activities in the American Expeditionary Forces from August, 1917, to January 5, 1919.

LIEUT.-COL. F. W. SCHEIDENHELM, *Engineers.*

Water Supply Section, Office of Chief Engineer, American Expeditionary Forces, November 22, 1917, to March 20, 1918, spending month of December, 1917, observing water-supply work of British Third Army in front of Cambrai; Water Supply Officer, Office of Chief Engineer, I Corps, March 20, 1918, to July 5, 1918; Assistant to Chief Engineer, First Army, July, 1918; Assistant to Chief Engineer, Second Army, August 1 to 10, 1918; Water Supply Officer, First Army, August 10 to October 3, 1918, but continued to perform the duties of this office, after assuming command of the 26th Engineers, until November 20, 1918.

MAJOR DWIGHT HORTON, *Engineers.*

Water Supply Officer, Northern Sector (Argonne-Meuse front), Water Supply Service, First Army, September 18 to December 20, 1918.

MAJOR NORMAN E. OLDS, *Engineers.*

Assistant Water Supply Officer, Office of Chief Engineer, First Army, August 22 to November 20, 1918, and Water Supply Officer subsequently.

MAJOR ARTHUR H. PRATT, *Engineers.*

Assistant to Chief Engineer, Second Army, as Officer in Charge, Water Department, August 4 to December 20, 1918.

CAPT. GEO. F. CATLETT, *Engineers.*

Assistant to Officer in Charge, Water Supply Section, Office of Chief Engineer, American Expeditionary Forces, assigned to study of water purification for troops operating in the Zone of the Armies, November, 1917, to March, 1918; Sanitary Officer, Intermediate Section, Services of Supply, in charge of water testing, inspection, and purification, April 1, 1918, to January 2, 1919.

CAPT. H. E. CHAMBERS, JR., *Engineers.*

Supply Officer, Water Supply Service, Office of Chief Engineer, First Army, October 20 to November 20, 1918.

CAPT. BENJAMIN M. HALL, JR., *Engineers.*

Assistant to Engineer in Charge, St. Nazaire Water Supply Project, France, November, 1917, to August, 1918; Assistant to Officer in Charge, Water Department, Office of Chief Engineer, Second Army, October to December, 1918; Officer in Charge, Water Supply Section, Division of Military Engineering and Engineer Supply, Office of Chief Engineer, American Expeditionary Forces, January 5, 1919, to May, 1919.

CAPT. G. W. KNIGHT, *Engineers.*

Water Supply Section, Office of Chief Engineer, American Expeditionary Forces, November 1917, to March, 1918; Liaison Officer at General Engineer Depot, War Department, Washington, D. C., April and May, 1918; Adjutant, Office of Chief Engineer Second Army, American Expeditionary Forces, July to December, 1918.

CAPT. CHARLES H. LEE, *Engineers.*

Water Resources, Water Supply Section, Office of Chief Engineer, American Expeditionary Forces, November, 1917, to June, 1918, including temporary service as Water Supply Officer, Office of Chief Engineer, I Corps, February to March, 1918; Water Intelligence Officer, Water Supply Service, Office of Chief Engineer, First Army, July to November, 1918.

Capt. W. M. Shallcross, *Engineers.*
Supply Officer, Water Supply Service, Office of Chief Engineer, First Army, September 23 to October 27, 1918; Supply Officer, Water Department, Office of Chief Engineer, Second Army, October 27 to December 20, 1918.

Capt. George W. Stickney, *Engineers.*
Assistant to Officer in Charge of Water Supply, Office of Director of Construction and Forestry, Services of Supply, May 18 to October 19, 1918.

Capt. A. D. Weston, *Engineers.*
Assistant to Officer in Charge, Water Supply Section, Division of Military Engineering and Engineer Supply, Office of Chief Engineer, American Expeditionary Forces, in connection with water-supply material and equipment, November, 1917, to September, 1918.

1st Lieut. F. O. Church, *Engineers.*
Water Supply Officer, Office of Chief Engineer, First Army, January and February, 1919.

1st Lieut. Frederick A. Fletcher, *Engineers.*
Assistant Water Transport Officer, Water Supply Service, Office of Chief Engineer, First Army, September 20 to November 20, 1918.

1st Lieut. A. R. Garnock, *Engineers.*
Water Transport Officer, Water Supply Service, Office of Chief Engineer, First Army, September to November, 1918.

1st. Lieut. Russell P. Hastings, *Engineers.*
Assistant Supply Officer, Water Supply Service, Office of Chief Engineer, First Army, September to November, 1918.

1st Lieut. P. O'B. Montgomery, *Engineers.*
Assistant to Chief Engineer, Advance Section, Services of Supply, August 10 to September 25, 1918.

1st Lieut. R. J. O'Meara, *Engineers.*
Officer in Charge, Water Supply Section, Engineer Depot at Gievres, France, January to August, 1918; Assistant to Adjutant, Office of Chief Engineer, Second Army, August to December, 1918.

1st Lieut. G. L. Rounds, *Engineers.*
Supply Officer, Northern Sector, Water Supply Service, First Army, September 19 to November 15, 1918.

2d Lieut. R. S. Nessler, *Engineers.*
Assistant to Officer in Charge, Engineer Depot, St. Nazaire, France, November, 1917, to September, 1918.

2d Lieut. Charles S. Beck, *Engineers.*
Assistant to Engineer in Charge, St. Nazaire Water Supply Project, France, November, 1917, to August, 1918.

CITATIONS.

HEADQUARTERS, 26TH ENGINEERS,
A.P.O. 774.

General Orders }
No. 2. } 1 DECEMBER, 1918.

1. The Commanding Officer takes pride in publishing the following letter for the information of all members of this command:

HEADQUARTERS, FIRST ARMY.

OFFICE OF CHIEF ENGINEER.

23 NOVEMBER, 1918.

From: The Chief Engineer, First Army.
To: The Commanding Officer, 26th Engineers.
Subject: Services rendered during offensives.

1. The Chief Engineer desires to express his highest appreciation to you and to your regiment for the services rendered by you to the First Army in connection with the St. Mihiel offensive, starting September 12, and the offensive between the Meuse and the Argonne, starting September 26, and the continuation of that offensive on November 1.

2. The success of these offensives is largely due to the excellent work performed by your regiment and its attached troops.

3. A copy of this letter has been sent to the Chief of Staff, First Army.

4. It is desired that the terms of this letter be published to all the officers and enlisted men of your command at the earliest opportunity.

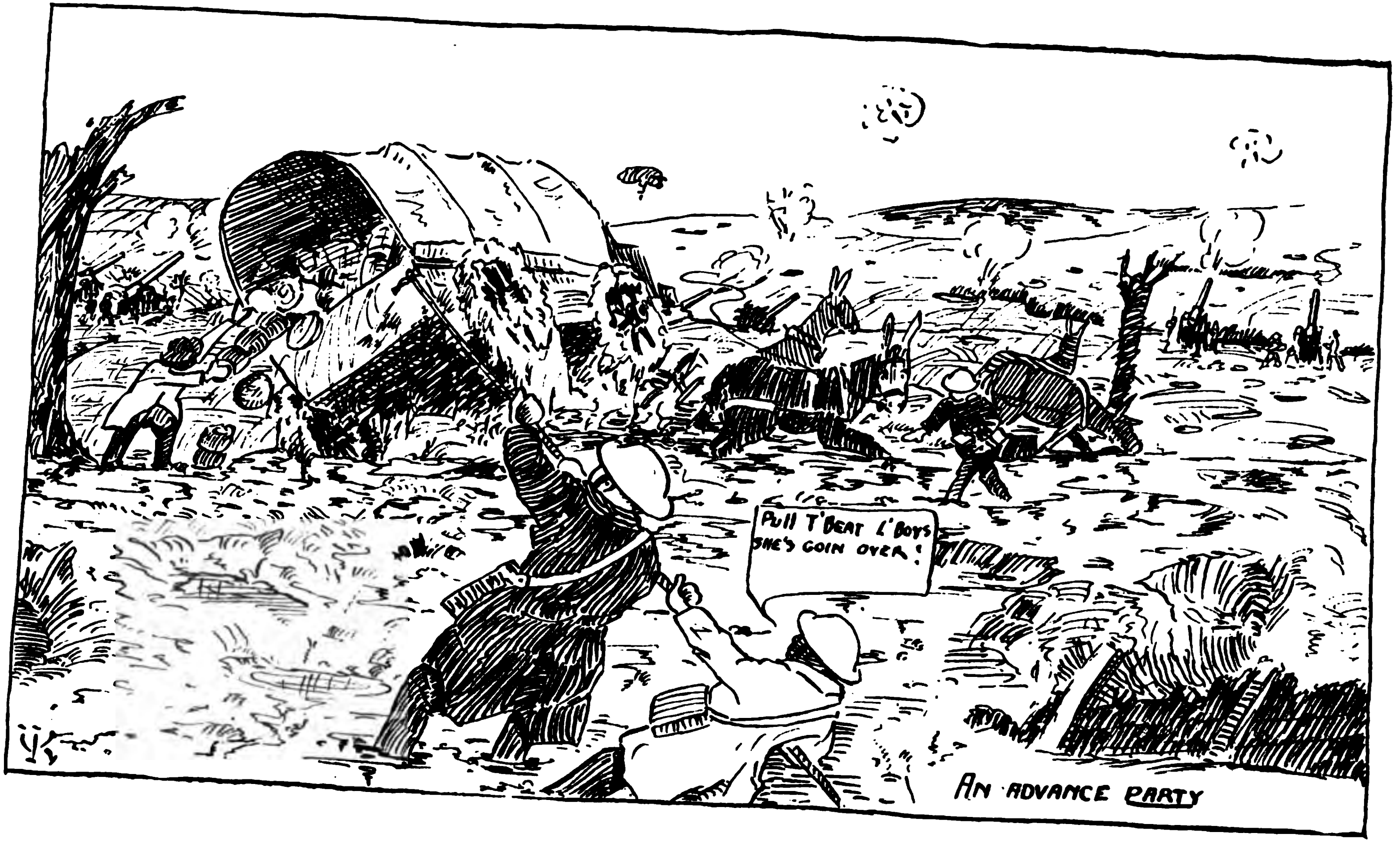
GEORGE R. SPALDING,
Colonel, Engineers, U. S. A.

2. The service of the command was to a large extent within the area of enemy shell fire, and yet, due to the fact that the command is one of army troops and to the conditions of campaign, neither relief nor rest was possible from the beginning to the end of operations.

3. The Commanding Officer desires to express his personal appreciation of the loyal, sustained, and effective efforts and co-operation of the officers and soldiers of this command, of those attached to this command, and of those otherwise associated with it in the First Army Water Supply Service.

By order of LIEUT.-COL. SCHEIDENHELM.

FRED S. WELLS,
1st Lt. Engrs., U.S.A., Adjutant.



AN ADVANCE PARTY

HEADQUARTERS, 26TH ENGINEERS,
BORDEAUX EMBARKATION CAMP,
AM.E.F.

26 FEB., '19.

General Orders
No. 6.

1. Under date of 17 Feb., '19, a letter has been received by the Commanding Officer from Major-General W. C. Langfitt, Chief Engineer, American Expeditionary Forces, from which letter the following is quoted for the information of the command:

> " Your regiment had a most important duty to perform in regard to water supply, both in the Services of Supply and in the armies. The duties required energy and high technical knowledge, and many times required the breaking up of your command into detachments, which could only have succeeded in their work by having excellent discipline.
>
> " I want you and your command to know that the services rendered were highly satisfactory and deserve commendation."

2. Applying broadly, as it does, to all of the work of the regiment in France, the commendation of so high an authority is properly a cause for gratification on the part of each member.

By order of LIEUT.-COL. SCHEIDENHELM.

(Signed) FRED S. WELLS,
1st Lt. Engrs., Adjutant.

HEADQUARTERS, 26TH ENGINEERS,
BORDEAUX EMBARKATION CAMP,
AM.E.F.

1 MARCH, 1919.

General Orders }
No. 7. }

1. During his inspection of this organization this date, at the Bordeaux Embarkation Camp, General J. J. Pershing, Commander-in-Chief, American Expeditionary Forces, expressed his desire that the Commanding Officer make known to the members of this command the entire satisfaction of the Commander-in-Chief with the work of this organization as Army Water Supply Troops with the several American armies.

2. The emphatic point in the comment of the Commander-in-Chief was that he had heard of no shortage of water at the front.

By order of LIEUT.-COL. SCHEIDENHELM.

(Signed) FRED S. WELLS,
1st Lt. Engrs., Adjutant.

General Orders No. 59.

WAR DEPARTMENT,
WASHINGTON, May 3, 1919.

VI. — AWARDS OF DISTINGUISHED-SERVICE MEDAL. — By direction of the President, under the provisions of the act of Congress approved July 9, 1918 (Bul. No. 43, W.D., 1918), the distinguished-service medal was awarded by the commanding general, American Expeditionary Forces, to the following-named officers:

Francis F. Longley, Colonel, United States Army. For exceptionally meritorious and distinguished services. He has been in charge of the Water Supply Service, and as commanding officer of the 26th Engineers, a water-supply regiment, since the fall of 1917. His untiring energy, unusual initiative, and good judgment have, to a marked degree, been responsible for the plentiful supply of pure drinking water to the combatant troops, thereby materially assisting in maintaining the unusually low rates in sickness among our troops.

By order of the Secretary of War:

FRANK McINTYRE,
Major-General, Acting Chief of Staff.

Official:
J. T. KERR,
Adjutant-General.

UNITED STATES ARMY.

CITATION.

Lieut.-Col. Frederick W. Scheidenhelm. For exceptionally meritorious and conspicuous services as Water Supply Officer, First Army, France, American Expeditionary Forces.

In testimony thereof, and as an expression of appreciation of these services, I award him this citation.

Awarded on 19 April, 1919.

(Signed) JOHN J. PERSHING,
Commander-in-Chief.

"LOOKING BACKWARD"

SOME REFLECTIONS OF THE CHAPLAIN.

The chaplain has tucked away, in his memory of our wartime experiences, a record of some rather unique services, and perhaps the men themselves will find a page or two devoted to their presence at some of these, in their own personally bound volume of recollections.

In the very beginning of the war for Company D, for example, we gathered together in a little shell-torn church in Sergy, — a church which some two weeks earlier had harbored a nest of hostile machine guns, — and here, seated or standing amid the débris, we held our service on a Sunday morn, encouraged thereto, no doubt, as we thought of the Alabama boys of the Rainbow Division taking their warriors' repose on the near-by hillside. But, curiously enough, — and yet of such is life, — there is a touch of humor, too, in the memory of that day. A company of pioneers joined us in our devotions, and minister-like, I was pleased to have the increase in the size of my anticipated congregation, and said as much to our visitors. And then their reply: " Yes, the captain gave us our choice, to work on the road or go to church, so here we are."

Again, some of you will remember another Sunday morning, when some forty or fifty of us gathered at the mouth of those dirty little dugouts not far from Bethincourt, and during the service our vagrant eyes noted the circling approach of some 'planes in the fleecy clouded skies. Nor was it long before the intermittent whirr of the engines told us of their Teutonic origin. But not until the closing prayer were the disconcerting guns let loose, the sharp biting rat-tat-tat of our own nearby anti-aircraft guns and the response in kind from the sky above.

And, once again, I remember a service held one Sunday afternoon on an open hillside near a certain, or uncertain, windmill between Nantillois and Montfaucon. There were two detachments of Company F there at the time; and at our gathering that afternoon there were some of the men from a detachment of Com-

pany D, who that very morning had seen five of their number laid low by a single shell. It was one of those times — in one of those seven long weeks of work and worry — when, somehow, a fellow rather felt the need of a little something other and different from those things of hideous sight, or more fearful sound, which had been the lot of our Engineers throughout the whole Argonne-Meuse offensive. And a little church gave him his chance. And

ANIMAL WATERING POINT.

One km. south of Montfaucon, showing stone-paved approaches on each side. Shell hole at left.

yet, even then it was hard to escape into that other world of peace and security, for the Hun kept planting his " big ones " along the brow and on the reverse side of our own particular hill. Rather hard to keep your mind from rambling from a religious center. Supposing one of the " big ones " should clear the hilltop, — what then? Well, so much the more reason to take God into account!

But it is impossible to enumerate them all — the different services which the chaplain will always remember, held up and down the front with the different and small circles of our men. Sometimes we assembled in a dugout or in a dugout's mouth, sometimes in the open, or in a billet, or stable, or barracks. But to me it was all so good, these services, in the time of our active warfare.

It all seemed so simple and natural and real and comforting and right.

And to me, too, those more trying and hard days were the happiest of my army life. It gave us a chance — officers, chaplain, and men — to get acquainted; for it threw us together into one and the same family life, with one and the same hard conditions to meet. It peeled off much of the artificial wrappings of life and dump-heaped a whole lot of its " bunk." It got us all down to the " First things first;" to the things that count, and gave us in return a religion couched in the terms of the big and simple things of life. At least, so your chaplain felt it to be. And for these things that he has seen and learned with you and through you, he thanks you, dear old " rough-neck engineers."

H. H. D. STERRETT.

CUSTOMERS OF A WATER PURIFICATION TRUCK.

"Chloropump" in background. On right, a company water cart. On left, an ammunition truck converted into a water wagon by means of French wine casks.

HISTORICAL STAFF,

26TH ENGINEERS.

Editor.

CAPT. CHARLES H. LEE,
Regimental Headquarters.

Treasurer.

2d LIEUT. HARRY J. ANGELL, Company E.

Contributors.

1st Lieut. Warren G. Baxter, Co. B.

Capt. H. E. Chambers, Jr., Rg. Hqs.

Mast. Eng. Sr. Gr. P. O. Davis, for Co. C.

Sergt. Lloyd P. Eynon, Co. B.

1st Lieut. Raymond Foulkrod, Co. D.

Major A. A. Fricke, Med. Detach.

1st Lieut. P. O'B. Montgomery, Co. A.

Rg. Sergt.-Major S. S. Noblit, Rg. Hqs.

Capt. T. B. Parker, Co. D.

Chaplain H. H. D. Sterrett, Rg. Hqs.

1st Lieut. F. J. Stewart, Co. F.

Mast. Eng. Jr. Gr. E. E. Suits, for Co. E.

2d Lieut. W. H. Withington, Co. F.

Artists.

Pvt. 1st Cl. Victor Kahill, Co. E.

Pvt. 1st Cl. W. C. Kensler, Co. D.

Draftsman.

Mast. Eng. Sr. Gr. F. Hapgood, 2d Bn. Hqs.

Statisticians.

Corp. V. F. Kemmet, Co. C.

Corp. T. W. Weigle, 2d Bn. Hqs.

Stenographers.

Corp. V. F. Kemmet, Co. C.

Corp. R. J. Pritchard, 1st Bn. Hqs.


MUST BE
CHLORINATED
FINISH

REGIMENTAL ROSTER.

26TH ENGINEERS.

NOTE: The following abbreviations are used in the roster: Adjt., Adjutant; A.S.C., Army Service Corps; Bn., Battalion; Co., Company; Col. Sgt., Color Sergeant; C.O., Commanding Officer; Corp., Corporal; D.S., Detached Service; Engrs., Engineers; Hosp., Hospital; Hqs., Headquarters; Hrshr., Horseshoer; Inf., Infantry; Lt., Lieutenant; Med. C., Medical Corps; M.E.J.G., Master Engineer Junior Grade; M.E.S.G., Master Engineer Senior Grade; Mess Sgt., Mess Sergeant; M.T.C., Motor Transport Corps; Pvt., Private; Pvt. 1 Cl., Private 1st Class; Rg., Regiment; Rg. Hqs., Regimental Headquarters; Sad., Saddler; San. C., Sanitary Corps; Sgt., Sergeant; Sgt. 1 Cl., Sergeant 1st Class; Sgt.-Maj., Sergeant-Major; Sgt. Bugl., Sergeant Bugler; Stb. Sgt., Stable Sergeant; Sup. Sgt., Supply Sergeant; Spec. Det., Specialist Detachment; Wag., Wagoner.

OFFICER PERSONNEL.

[1] Relieved from duty with Rg., October 16, 1918.
[2] Commissioned in France. Assigned December 12, 1918.
[3] Relieved from duty with Rg., January, 1919.
[4] Attached October, 1918. Relieved from duty with Rg., February, 1919.
[5] Relieved from duty with Rg., July, 1918.
[6] Commissioned in France. Relieved from duty with Rg., November 28, 1918.
[7] Assigned to Rg., November 20, 1918.
[8] Transferred to 44th F.A., March 31, 1918.
[9] Relieved from duty with Rg., October 16, 1918.
[10] Relieved from assignment with Rg., January, 1919.
[11] Relieved from duty with Rg., December, 1917. Did not leave U. S.
[12] Relieved from duty with Rg., November 20, 1918.
[13] Relieved from duty with Rg., December 21, 1917.
[14] Relieved from duty with Rg., November 20, 1918. Promoted to Major, Engrs., February, 1919.
[15] Commissioned in France.
[16] Died November 17, 1918, of wounds received in action November 4, 1918.

Name.	Grade and Company or Detachment on Leaving U. S.	Feb. 1, '19.	Address.
Angell, Harry J.	2d Lt. Co. E	2d Lt. Co. E	16 Murray St., N. Y. City, N. Y.
Barnes, Frederick B.	M.E.J.G. Rg. Hqs.	2d Lt. Co. D	108 E. 17th St., N. Y. City, N. Y.
Baxter, Warren G.	1st Lt. Co. B	1st Lt. C.O. Co. B	1104 Turkshead Bldg., Providence, R. I.
Beck, Charles S.	2d Lt. Co. B	2d Lt. Co. B	c/o Peerless Steel Co., Ardmore, Okla.
Benedict, Sydney	2d Lt. Co. C	2d Lt. Co. C	2651 49th St., S.E., Portland, Ore.
Blake, James E.	Corp. Co. C	2d Lt. Co. F	Marcus Hook, Pa.
[1]Boettger, Robert	Captain Rg. Adjt.		131 Alta Ave., Yonkers, N. Y.
[2]Boyce, M. R.		2d Lt. Co. A	127 W. North Ave., Chicago, Ill.

Name.	Grade and Company or Detachment on Leaving U. S.	Feb. 1, '19.	Address.
Burge, J. D.	2d Lt. Engrs. Casual	1st Lt. 1st. Bn. Hqs.	Louisville, Ky.
Candee, Seth W.	1st Sgt. Co. B	2d Lt. Co. B	1614 N. Felton St., Philadelphia, Pa.
Catlett, George F.	Captain on D.S.	Captain Rg. Hqs. (attached)	P. O. Box 687, Wilmington, N. C.
Chambers, H. E., Jr.	Captain Co. A	Captain Rg. Hqs.	c/o A. M. Lockett Co., Houston, Tex.
Chandler, Robert V.	Sgt. Co. C	2d Lt. M.T.C. Rg. Hqs.	1216 Van Ness St., San Francisco, Calif.
Church, Franklin O.	1st Lt. Co. B	1st Lt. Co. B	143 E. 39th St., N. Y. City, N. Y.
Cleveland, Lou B.	1st Lt. Engrs. Casual	1st Lt. 1st Bn. Hqs.	Watertown, N. Y.
[3]Colgan, William H.	1st Lt. San. C. Co. D (attached)		29 Carver St., Astoria, Borough of Queens, N. Y. City, N. Y.
[4]Cowan, Vern L.	1st Lt. Dental C.	1st Lt. Dental C. (attached)	318 Whiting Bldg., Springfield, Mass.
[3]Crowell, Milton J.	1st Lt. San. C. Co. B (attached)		Melrose, Mass.
[5]Dent, Elliott J.	Colonel Commanding Regiment		Major, Corps of Engineers, 329 Customhouse, New Orleans, La.
Eckert, Alfred C.	2d Lt. Inf. Casual	2d Lt. Engrs. Co. A	916 South 4th St., Saginaw, Mich.
Ericsson, Clarence E.	2d Lt. Co. F	2d Lt. Co. F	643 Waveland Ave., Chicago, Ill.
Field, Ralph E.	2d Lt. Engrs. Casual	2d Lt. Co. A	2060 Elm St., Cincinnati, Ohio.
[6]Finger, Matt.	Sgt. Co. C	2d Lt. A.S.C.	2015 Harrison St., Wilmington, Del.
[7]Fletcher, Frederick A.	2d Lt. Signal C.	1st Lt. Co. F	1408 Lexington Bldg., Baltimore, Md.
Forde, Charles W., Jr.	2d Lt. Co. B	2d Lt. Co. B	Milford, Ohio.
Forfar, Donald M.	1st Lt. Co. E	1st Lt. Co. E	Virginia, Minn.
Foulkrod, Raymond	1st Lt. Co. D	1st Lt. Co. D	Wynnewood, Pa.

Name.	Grade and Company or Detachment on Leaving U. S.	Grade and Company or Detachment on Feb. 1, '19.	Address.
Fricke, Albert A.	Major Med. C. Rg. Surg.	Major Med. C. Rg. Surg.	1789 W. 25th St., Los Angeles, Calif.
Garnock, Alexander R.	1st Lt. Engrs. Casual	1st Lt. Co. E	Eau Claire, Wis.
Gash, Frank T.	1st Lt. Co. E	1st Lt. Co. E	132 W. 7th Ave., Tarentum, Pa.
Hall, Benjamin H., Jr.	1st Lt. Co. B	Captain 1st Bn. Adjt.	c/o B. M. Hall & Sons, Atlanta, Ga.
Hastings, Russell P.	1st Lt. Co. D	1st Lt. 2d Bn. Hqs.	125 E. Broadway, Anaheim, Calif.
[9]Hillis, Samuel	1st Lt. Med. C.		(Unknown.)
Hodnett, Ralph M.	2d Lt. Engrs. Casual		Minneapolis, Minn.
Horton, Dwight	Captain Co. F	Major C.O. 2d Bn.	101 Main St., Dallas, Tex.
Howard, Royal M.	Pvt. 1 Cl. Co. C	2d Lt. Co. B	814 Greene Ave., Brooklyn, N. Y.
Hughes, Lucien G.	Sgt. 1 Cl. Co. C	2d Lt. Co. F	Box 536, Eastland, Tex.
Jewell, A. H.	1st Lt. San. C. Co. F	1st Lt. San. C. Co. F (attached)	359 Abbott St., East Lansing, Mich.
Johnson, Frank C. C.	2d Lt. Co. A	2d Lt. Co. A	2548 Maple Ave., N.S., Pittsburgh, Pa.
[9]Knapp, Arthur	Captain Co. E		230 Wall St., Shreveport, La.
Knight, Gerald W.	Captain on D.S.	Captain Rg. Hqs.	Chattanooga, Tenn.
Lee, Charles H.	1st Lt. on D.S.	Captain Rg. Hqs.	2629 Piedmont Ave., Berkeley, Calif.
Letton, Harry P.	Captain Engrs. Casual	Captain Rg. Hqs.	1921 S. 16th St., Lincoln, Neb.
Levine, Lionel M.	1st Lt. Co. F	1st Lt. Co. F	530 Manhattan Ave., N. Y. City, N. Y.
[10]Longley, Francis F.	Major Engrs. Casual	Colonel Engrs.	c/o League of Red Cross Societies, Geneva, Switzerland.
Loughlin, William C.	2d Lt. Co. C	2d Lt. Co. C	1111 Marquette Bldg., Chicago, Ill.
Loughran, V. J.	1st Lt. San. C. Co. C	1st Lt. San. C. Co. C (attached)	199 Stryker Ave., Woodside, L. I., N. Y.

Name.	Grade and Company or Detachment on Leaving U. S.	Feb. 1, '19.	Address.
Montgomery, P. O'B.	1st Lt. Co. A	1st Lt. C.O. Co. A	3915 Irving Ave., Dallas, Tex.
Murray, Joseph I.	Sgt. San. C. Co. F	2d Lt. San. C. Co. F (attached)	(Unknown.)
[11]Nicholas, R. V.	Major C. of E.		Captain, Corps of Engineers, 1206 10th St., Huntington, W. Va.
[12]Nessler, R. L.	2d Lt. Co. A		St. Louis, Mo.
[13]Norcum, G. D.	1st Lt. San. C. Co. A (attached)		(Unknown.)
[14]Olds, Norman E.	Captain Rg. Hqs.		16 Mountain Ave., Summit, N. J.
O'Meara, Robert J.	1st Lt. Co A	1st Lt. Co. A	311 E. 124th St., N. Y. City, N. Y.
Parker, Theodore B.	1st Lt. Co. D	Captain Co. D	6 Locust St., Flushing, N. Y.
Pratt, Arthur H.	Captain Co. B	Major C. O. 1st Bn.	20 Clinton St., Newark, N. J.
Pritchard, John C.	Captain Co. D	Captain Co. E	Apartado 135, Tampico, Mex.
[15]Rapp, William J.		2d Lt. San. C. Med. C. (attached)	35 Clifton Place, Brooklyn, N. Y.
Rosenfeld, James R.	2d Lt. Co. D	2d Lt. Co. D	c/o Equitable Life Assurance Society, Pittsburgh, Pa.
Rounds, Garland L.	1st Lt. Co. F	1st Lt. 2d Bn. Adjt.	Merriam Block, Council Bluffs, Ia.
Scheidenhelm, F. W.	Captain (attached) on D.S.	Lt.-Col. Commanding Regiment	10944 Hilburn St., Hollis, N. Y. City, N. Y.
Schoonover, W. R.		2d Lt. San. C. (attached)	Agricultural Bldg., Univ. of Ill., Urbana, Ill.
Sellnow, Frank C.	2d Lt. Co. E	2d Lt. Co. E	115 Mulberry St., Newark, N. J.
Shafer, Ernest A.	1st Lt. Co. C	1st Lt. Co. C	886 Mills Bldg., San Francisco, Calif.

Name.	Grade and Company or Detachment on Leaving U. S.	Feb. 1, '19.	Address.
Shallcross, Wilbur M.	Captain Rg. Hqs.	Captain 2d Bn. Hqs.	680 49th St., Milwaukee, Wis.
Sheldon, Howard G.	Sgt. Co. C	2d Lt. Co. C	2720 Midland Ave., Syracuse, N. Y.
Smith, Cromwell O.	2d Lt. 114 Engrs.	2d. Lt. Co. E	Moorhead, Miss.
Sterrett, Henry H. D.	1st Lt. Rg. Chaplain	1st Lt.	3025 Macomb Ave., Washington, D. C.
Stevens, Glenn R.	2d Lt. Co. D	2d Lt. Co. D	5 Myrtle Ave., Newark, N. Y.
Stewart, Fred J.	1st Lt. Co. F	1st Lt. C.O. Co. F	Centerville, Ia.
Stickney, Grosvenor W.	Captain Co. C	Captain Co. C	Room 500, 17 N. La Salle St., Chicago, Ill.
Stover, F. H.		1st Lt. San. C. (attached)	(Unknown.)
[16]Tinsman, Joseph A.	1st Lt. San. C. Co. E (attached)		411 N. Centre St., Merchantville, N. J.
Thompson, David S.	Sgt. Co. C	2d Lt. Co. D	919 N. Elmwood St., Tulsa, Okla.
Wells, Fred S.	1st Lt. Co. C	1st Lt. Rg. Adjt.	c/o Stephens-Adamson Co., 50 Church St., N. Y. City, N. Y.
Wesson, M. B.		Captain Med. C.	(Unknown.)
[8]Weston, Arthur D.	1st Lt. Co. A	Captain 34th Engrs.	c/o State Board of Health, State House, Boston, Mass.
Willard, Rees W.	1st Lt. Co. C	1st Lt. Co. C	Municipal Bldg., Dallas, Tex.
Withington, William H.	2d Lt. Co. F	2d Lt. Co. F	480 Lexington Ave., N. Y. City, N. Y.

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